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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

AUG 14 1992

OFFICE OF WATER

MEMORANDUM

SUBJECT: Clarifications Regarding Certain Aspects of EPA's Surface Water Toxics Control Regulations

FROM: for Michael B. Cook, Director
Office of Wastewater Enforcement And Compliance

Robert H. Wayland, III, Director
Office of Wetlands, Oceans and Watersheds

TO: Water Management Division Directors, Regions I-X

Attached is a set of clarifications relating to five issues associated with EPA's Surface Water Toxics Control Regulations. Each clarification concerns aspects of EPA's regulations relating to section 304(l) and water quality-based effluent limitations.

These clarifications are being issued by EPA in connection with negotiations between EPA and petitioners in the case of American Paper Institute v. EPA (No. 89-1499), which is pending in the U.S. Court of Appeals for the D.C. Circuit. In return, petitioners have agreed not to brief the issues that are subject to these clarifications in the aforementioned case.

Your offices should refer to these clarifications when applying the regulations to which they correspond. We also ask that you distribute these clarifications to the States within your respective regions.

cc: Regional Counsel Water Branch Chiefs, Regions I-X

CLARIFICATIONS

1. ISSUE: The definition of whole effluent toxicity in 40 C.F.R. § 122.2.

CLARIFICATION:

EPA defined whole effluent toxicity in 40 C.F.R. § 122.2 as the "aggregate toxic effect of an effluent measured directly by a toxicity test." The petitioners were concerned that this definition, in conjunction with the requirement in 40 C.F.R. § 122.44(d)(1)(iv) and (v) that states implement narrative criteria by imposing limits on whole effluent toxicity, could be read expansively to require states to impose whole effluent toxicity limits prohibiting discharges which evoke any response in test organisms, no matter how slight, as measured by toxicity tests. The petitioners stated that such an interpretation could deprive a state of the authority to define what it considers to be acceptable levels of toxicity in a discharger's effluent consistent with applicable water quality standards. EPA does not interpret the definition of whole effluent toxicity in section 122.2, or the requirements of section 122.44(d)(1)(iv) and (v), as imposing any substantive water quality standard for what constitutes an acceptable level of whole effluent toxicity. Rather, these sections indicate when the permitting authority must establish permit limits on whole effluent toxicity for purposes of achieving water quality standards (either numeric or narrative water quality criteria).

2. ISSUE: The enforceability of limitations based upon single toxicity test results, as discussed at 54 Fed. Reg. 23,871.

CLARIFICATION:

In the preamble to the final rule, at 54 Fed. Reg. 23,871, EPA stated that:

> A limit on whole effluent toxicity refers to a numeric effluent limitation expressed in terms such as toxic units, no observed effect level (NOEL), LC 50, or percent mortality. Effluent limitations may be expressed as chronic toxicity or acute toxicity (or both). Regardless of how the numeric limitations for whole effluent toxicity are expressed, any single violation of an effluent limit is a violation of the NPDES permit and is subject to the full range of state and Federal enforcement actions.

EPA interprets this paragraph and existing regulations to provide that violation of an effluent limit for whole effluent toxicity is enforceable, whether that limit is expressed in terms of a numeric effluent limit or, where setting a numeric effluent limit is infeasible, best management practices. (For example, some storm water discharges have volumes and pollutant concentrations that fluctuate wildly with storm events, making it difficult to document resulting water quality impacts.) The preamble statement does not address the issue of how permit limits may be derived. For example, when used appropriately, permit limits may include averages (e.g., monthly averages) which may be exceeded by an individual measurement so long as the average of the individual measurements is not above the limit and any applicable daily maximum is complied with. Permit limits, however expressed, must be designed to protect water quality standards.

3. ISSUE: The requirement for limitations on all pollutants and the use of indicators, as set forth at 40 C.F.R. § 122.44(d)(1)(i).

CLARIFICATION:

40 C.F.R. § 122.44(d)(1)(i) requires that permits contain effluent limitations to control pollutants that "are or may be" discharged at levels having the "reasonable potential to cause, or contribute to an excursion above any State water quality standard, including State narrative criteria for water quality."

EPA did not intend to require water quality-based permit limitations on all pollutants contained in a discharge through the promulgation of the June 2, 1989 regulation; nor do we believe that the regulation has that effect. The proper interpretation of the regulations is that developing water quality-based limitations is a step-by-step process. First, the permitting authority must evaluate all available information to determine at what level pollutants are expected to exist in the current discharge. This determination is governed by 40 C.F.R. § 122.44(d)(1)(ii). The goal of this step is to estimate the levels of pollutants in the effluent as discharged at the time of permit application, or with any projected increases in the discharge.

Under 40 C.F.R. § 122.44(d)(1)(ii), the permitting authority must take into account the likely variability of the pollutant in the effluent, other current discharges (from both point and non-point sources as well as natural background), and (where appropriate) dilution. At the end of this step the permitting authority will have estimated an in-stream level of the pollutant (or pollutant parameter) of concern that has the reasonable potential to occur as a result of the discharge. (Most of this

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[1] The technological or economic feasibility of a discharger meeting numeric limitations is not relevant to this determination.

step may have already been completed as a part of the total maximum daily load and wasteload allocation calculation.) If the estimated in-stream levels (which may occur, but will not necessarily occur) would exceed any applicable water quality criterion, including the narrative criteria, then the permitting authority must go to the next step and establish a water quality-based limit in accordance with paragraphs 122.44(d)(1)(iii)-(vi).

EPA does not interpret section 122.44(d)(1)(i) as requiring that permits contain water quality-based limitations on every pollutant that may be present in a given effluent. Rather, water quality-based limits are established where the permitting authority reasonably anticipates the discharge of pollutants by the permittee at levels that have the reasonable potential to cause or contribute to an excursion above any state water quality criterion, including state narrative criteria for water quality. 40 C.F.R. § 122.44(d)(1)(i). The permitting authority should evaluate the reasonable potential for an excursion above a water quality criterion in light of the character of the effluent as discharged.

4. ISSUE: The use of a state policy or regulation interpreting state narrative water quality criteria, as set forth at 40 C.F.R. § 122.44(d)(1)(vi)(A).

CLARIFICATION:

The final rule provides that a permitting authority must establish permit limits using one or more of several options whenever a specific chemical for which the state has not established a water quality criterion is present in an effluent at a concentration that causes, has the reasonable potential to cause, or contributes to an excursion above a state narrative criterion. 40 C.F.R. § 122.44(d)(1)(vi). The rule then prescribes several options for establishing permit limitations, including "explicit State policy or regulation interpreting [the State's] narrative water quality criterion . . . ." 54 Fed. Reg. at 23,896, codified at 40 C.F.R. § 122.44(d)(1)(vi)(A).

EPA interprets section 122.44(d)(1)(vi) as requiring permit writers to use a formally adopted state regulation or policy (including any state waste load allocation approved by EPA or established by EPA using formally-adopted state regulations or polices, where available) for deriving a chemical-specific numeric water quality-based effluent limitation from an applicable narrative standard in lieu of the other options for interpreting a narrative standard set forth in that section, if such a formally-adopted state regulation or policy exists. Such a regulation or policy would typically be part of either a state's water quality standards or total maximum daily load for the water body in question, and would be subject to EPA approval or disapproval in accordance with 40 C.F.R. Parts 130 or 131. If the state had not formally adopted a state regulation or policy pursuant to 40 C.F.R. Parts 130 or 131, or if it has not been approved as part of the state NPDES program, the permit writer must develop limits, using any one of the options set forth in section 122.44(d)(1)(vi). Some of the industry petitioners in American Paper Institute v. U.S. EPA (D.C. Cir. No. 89-1499) and consolidated cases do not agree that a formally adopted state regulation or policy must be subject to EPA approval or disapproval before permit writers would be required to use the policy in developing limits. EPA expects this issue to be litigated in the permit context.

When a permit writer interprets a narrative standard, the method of interpretation used will be available for public comment as a part of the permit and typically may be appealed through administrative and judicial procedures available for review of NPDES permit conditions.

5. ISSUE: The standards for listing waters on the list of Clean Water Act ("CWA") section 304(l)(1)(B), 33 U.S.C. § 1314(l)(1)(B), as set out at 40 C.F.R. § 130.10(d)(5.

CLARIFICATION:

Section 304(l)(1)(B) of the CWA, 33 U.S.C. § 1314(l)(1)(B), provides that the state should list waters where an applicable water quality standard is exceeded "due entirely or substantially" to point sources. EPA's final rule requires listing of a water under section 304(l)(1)(B) where (1) water quality-based limits on one or more point sources would result in the water quality standard for a toxic pollutant being achieved, or (2) discharges from one or more point sources would be sufficient to cause or are expected to cause an exceedence of the water quality standard for a toxic pollutant, regardless of any contribution of the same pollutant from nonpoint sources. 54 Fed. Reg. at 23,897, codified at 40 C.F.R. § 130.10(d)(5).

The conditions in 40 C.F.R. § 130.10(d)(5) govern only the determination of whether or not a given water should be listed under section 304(l)(1)(B). Section 130.10 (d)(5) does not dictate the limitations to be included in an individual control strategy ("ICS"). ICSs may be developed in light of permit limits and nonpoint source requirements established through the total maximum daily load ("TMDL") process. The TMDL is a quantification of the capacity of a waterbody to assimilate pollutants based on the applicable water quality standard. The TMDL consists of the sum of wasteload allocations for point sources, load allocations for nonpoint sources, and natural background, with a margin of safety to account for uncertainty. Subject to EPA approval, if a state determines that reductions in the discharge of pollutants from a point source would be inequitable or prohibitively expensive, the state may adopt a

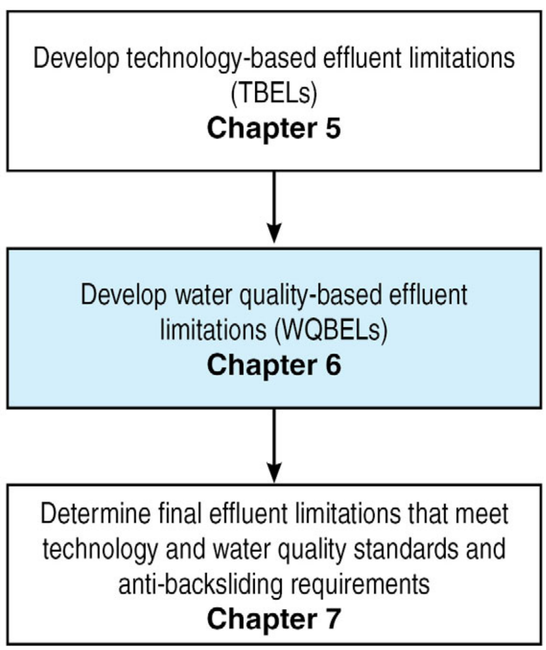
TMDL for achieving the water quality standards which relies in whole or in part upon control requirements on nonpoint sources. *See* 40 C.F.R. Section 130.7

CHAPTER 6. Water Quality-Based Effluent Limitations

When drafting a National Pollutant Discharge Elimination System (NPDES) permit, a permit writer must consider the impact of the proposed discharge on the quality of the receiving water. Water quality goals for a waterbody are defined by state water quality standards. By analyzing the effect of a discharge on the receiving water, a permit writer could find that technology-based effluent limitations (TBELs) alone will not achieve the applicable water quality standards. In such cases, the Clean Water Act (CWA) and its implementing regulations require development of water quality-based effluent limitations (WQBELs). WQBELs help meet the CWA objective of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters and the goal of water quality that provides for the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water (*fishable/swimmable*).

WQBELs are designed to protect water quality by ensuring that water quality standards are met in the receiving water. On the basis of the requirements of 40 CFR 125.3(a), additional or more stringent effluent limitations and conditions, such as WQBELs, are imposed when TBELs are not sufficient to protect water quality. Exhibit 6-1 illustrates the relationship between TBELs and WQBELs in an NPDES permit, as well as the determination of final effluent limitations.

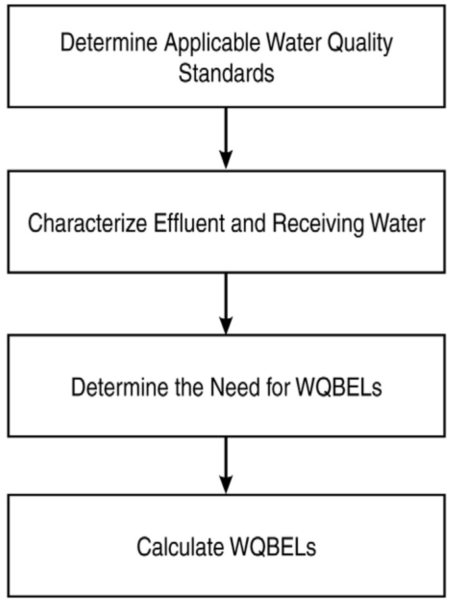
Exhibit 6-1 Developing effluent limitations



CWA section 301(b)(1)(C) requires that permits include any effluent limitations necessary to meet water quality standards. As illustrated above, to satisfy that requirement, permit writers implement a process to determine when existing effluent limitations (e.g., TBELs) and existing effluent quality are not sufficient to comply with water quality standards and to, where necessary, develop WQBELs. Exhibit 6-2 illustrates the four basic parts of the *standards-to-permits* process used to assess the need for and develop WQBELs.

After completing that process, the permit writer determines the final effluent limitations, includes any compliance schedules and interim effluent limitations, as appropriate, and documents all his or her decisions and calculations.

Exhibit 6-2 Standards-to-permits process



This chapter provides basic information on the standards-to-permits process. For more detailed information on water quality standards and water quality-based permitting, and some of the specific topics discussed in this chapter, refer to the NPDES Website <www.epa.gov/npdes> and Water Quality Standards Website <www.epa.gov/waterscience/standards>.

6.1 Determine Applicable Water Quality Standards

CWA section 303(c) and Title 40 of the *Code of Federal Regulations* (CFR) Part 131 establish the framework for water quality standards. The CWA and implementing regulations require states to develop and, from time to time, revise water quality standards applicable to waters of the United States, or segments of such waterbodies, that are in the jurisdiction of the state. States must review their water quality standards at least once every 3 years and revise them as appropriate. Wherever attainable, water quality standards should protect water quality that provides for the protection and propagation of fish, shellfish and wildlife, and recreation in and on the water (i.e., the CWA section 101(a)(2) *fishable/swimmable* goal). In establishing standards, states must consider the use and value of their waters for public water supplies, propagation of fish and wildlife, recreation, agriculture and industrial purposes, and navigation. The U.S. Environmental Protection Agency (EPA) has provided information regarding procedures for developing water quality standards in the Water Quality Standards Regulation at Part 131 and EPA's *Water Quality Standards Handbook: Second Edition*[1] <www.epa.gov/waterscience/library/wqstandards/handbook.pdf.> (hereafter *WQS Handbook*). Under CWA section 510, states may develop water quality standards that are more stringent than those required by the CWA.

EPA Regions review and approve or disapprove new and revised water quality standards adopted by states. The purpose of EPA's review is to ensure that the new and revised water quality standards meet the requirements of the CWA and the Water Quality Standards Regulation. Water quality standards adopted and submitted to EPA after May 30, 2000, must be approved by EPA before they may be used to implement the CWA (e.g., used in NPDES permitting). If an EPA Region disapproves a submitted new or revised state water quality standard, and the state does not adopt the necessary changes within 90 days of notification of the disapproval, EPA must promptly propose and promulgate a replacement standard [see § 131.22(a)].

When writing an NPDES permit, the permit writer must identify and use the state water quality standards in effect for CWA purposes. EPA maintains a compilation of current state water quality standards on the Water Quality Standards: State, Tribal, & Territorial Standards Website <www.epa.gov/waterscience/standards/wqslibrary/>. In addition, EPA's Water Quality Standards: Laws and Regulations Website <http://www.epa.gov/waterscience/standards/rules/> provides federally promulgated standards applicable to specific states. The remainder of this section provides permit writers with a general overview of water quality standards and how they are implemented in NPDES permits.

6.1.1 Components of Water Quality Standards

Water quality standards comprise three parts:

- Designated uses.
- Numeric and/or narrative water quality criteria.
- Antidegradation policy.

Each of those three components, along with general policies that also may be included in state water quality standards, is described below.

6.1.1.1 Designated Uses (§ 131.10)

The first part of a state's water quality standards is a classification system for waterbodies based on the expected uses of those waterbodies. The uses in this system are called *designated uses*. The regulations at § 131.10(a) describe various uses of waters that are considered desirable and that must be considered when establishing water quality standards. Those uses include public water supplies, propagation of fish, shellfish, and wildlife, recreation in and on the water, agricultural, industrial, and other purposes including navigation. The regulations allow states to designate more specific uses (e.g., cold water aquatic life) [see § 131.10(c)] or uses not specifically mentioned in the CWA, with the exception of waste transport and assimilation, which are not acceptable designated uses [see § 131.10(a)]. States must also consider and ensure the attainment and maintenance of the water quality standards of downstream waters when establishing designated uses [see § 131.10(b)].

The regulations in § 131.10(j) effectively establish a *rebuttable presumption* that the uses in CWA section 101(a)(2) (fishable/swimmable) are attainable. If a state fails to designate a given waterbody for such uses, or wishes to remove such uses, it must provide appropriate documentation demonstrating why such uses are not attainable. This analysis is commonly called a *Use Attainability Analysis* (UAA) (see § 131.3(g) and section 6.1.2.1 below.

6.1.1.2 Water Quality Criteria (§ 131.11)

The second part of a state's water quality standards is the set of water quality criteria sufficient to support the designated uses of each waterbody. EPA's Water Quality Standards Regulation at § 131.11(a) requires states to adopt water quality criteria using sound scientific rationale and to include sufficient parameters or constituents to protect the designated use. If a waterbody has multiple use designations, the criteria must support the most sensitive use. The regulation at § 131.11(b) allows states to adopt both numeric and narrative water quality criteria. Numeric water quality criteria are developed for specific parameters to protect aquatic life and human health and, in some cases, wildlife from the deleterious effects of pollutants. States establish narrative criteria where numeric criteria cannot be established, or to supplement numeric criteria. Criteria newly adopted or revised on or after May 30, 2000, do not become effective for purposes of the CWA until approved by EPA (see § 131.21(c)).

CWA section 304(a) directs EPA to develop, publish, and, from time to time, revise criteria for water quality accurately reflecting the latest scientific knowledge on the following:

- The kind and extent of all identifiable effects on health and welfare, including effects on aquatic life and recreational uses, that may be expected from the presence of pollutants in any body of water.
- The concentration and dispersal of pollutants or their byproducts through biological, physical, and chemical processes.
- The effects of pollutants on biological community diversity, productivity, and stability.

EPA's recommended criteria developed under CWA section 304(a) assist states in developing their water quality standards. EPA's numeric criteria are ambient levels of individual pollutants or parameters or they describe conditions of a waterbody that, if met, generally will protect the CWA section 101(a)(2) fishable and swimmable uses. EPA's recommended criteria developed under CWA section 304(a) do not reflect consideration of economic impacts or the technological feasibility of meeting the chemical concentrations in ambient water. EPA provides a table of the nationally recommended CWA section 304(a) criteria on the National Recommended Water Quality Criteria Website <www.epa.gov/waterscience/criteria/wqctable/>. The regulation at § 131.11(b)(1) indicates that, in establishing numeric criteria, states may (1) adopt EPA's recommended criteria published under CWA section 304(a), (2) adopt those criteria modified to reflect site-specific conditions, or (3) adopt criteria based on other scientifically defensible methods.

CWA section 303(c)(2)(B) specifically requires states to adopt numeric criteria for CWA section 307(a) toxic (priority) pollutants for which EPA has published recommended criteria if the discharge or presence of the pollutant can reasonably be expected to interfere with designated uses. Furthermore, § 131.11(a)(2) requires states to review water quality data and information on discharges to identify specific water bodies where toxic pollutants might be adversely affecting water quality or attainment of designated uses or where levels of toxic pollutants would warrant concern and to adopt criteria for such toxic pollutants applicable to the waterbody that are sufficient to protect the designated use. As discussed in section 1.2 and presented in Exhibit C-1 in Appendix C of this manual, the CWA section 307(a) list contains 65 compounds and families of compounds, which EPA has interpreted to include 126 toxic (priority) pollutants.

Numeric Criteria—Aquatic Life

Numeric criteria for the protection of aquatic life are designed to protect aquatic organisms, including both plants and animals. EPA's aquatic life criteria address both short-term (acute) and long-term (chronic) effects on both freshwater and saltwater species. Each of those criteria generally consists of three components:

- **Magnitude:** The level of pollutant (or pollutant parameter), usually expressed as a concentration, that is allowable.
- **Duration:** The period (averaging period) over which the in-stream concentration is averaged for comparison with criteria concentrations.
- **Frequency:** How often criteria may be exceeded.

Are criteria and effluent limitations expressed in the same terms?

Generally, criteria and effluent limitations are not expressed in the same terms. As discussed above, criteria are generally expressed as a magnitude, duration and frequency. Effluent limitations in NPDES permits are generally expressed as a magnitude (e.g., milligrams per liter, micrograms per liter) and an averaging period (e.g., maximum daily, average weekly, average monthly). A permit writer should be aware of the procedures used by his or her permitting authority to appropriately reflect the magnitude, duration, and frequency components of aquatic life criteria when determining the need for and calculating effluent limitations for NPDES permits. Typically, the components of the criteria are addressed in water quality models through the use of statistically derived receiving water and effluent flow values that ensure that criteria are met under *critical conditions* (see section 6.2 below).

Exhibit 6-3 is an example of freshwater aquatic life criteria for cadmium from the National Recommended Water Quality Criteria Website <www.epa.gov/waterscience/criteria/wqctable/> and at 66 FR 18935, April 12, 2001, Notice of Availability of 2001 Update: Aquatic Life Criteria Document for Cadmium <www.epa.gov/EPA-WATER/2001/April/Day-12/w9056.htm>.

Exhibit 6-3 Aquatic life criteria example: Cadmium (dissolved)

Except possibly where a locally important species is unusually sensitive, freshwater aquatic organisms and their uses should not be affected unacceptably if

Chronic criterion:
The 4-day average concentration (in micrograms per liter [µg/L]) does not exceed the numerical value given by $e^{(0.7409[\ln(\text{hardness})]-4.719)}$ (1.101672 – [(ln hardness)(0.041838)]) more than once every 3 years on average.

Acute criterion:
The 24-hour average concentration (in µg/L) does not exceed the numerical value given by $e^{(1.0166[\ln(\text{hardness})]-3.924)}$ (1.136672 – [(ln hardness)(0.041838)]) more than once every 3 years on average.

It is apparent that the acute and chronic aquatic life criteria for cadmium are not simply single numbers. Rather, they are expressed as a magnitude, a duration (4-day average or 24-hour average), and a frequency (not more than once every 3 years). Furthermore, the magnitude is expressed by a formula that is hardness-dependent, as is the case for most criteria for metals.

The magnitude of other aquatic life criteria can vary according to other conditions in the water or even based on the presence or absence of certain aquatic life. For example, EPA's 1999 recommended ammonia criteria vary according to pH, temperature, the presence or absence of salmonid species, and the presence or absence of early life stages of fish. A permit writer must be aware of the applicable criteria and any state regulations, policies, and procedures for interpreting numeric criteria and for implementing the criteria in NPDES permits. The durations of aquatic life criteria vary as well. For example, EPA's criteria recommendations for ammonia include a 30-day average chronic criterion. Also, many acute criteria for toxic pollutants are expressed as a 1-hour average. The frequency component of most aquatic life criteria specifies that they should be exceeded no more than once every three years.

Some states have adopted numeric criteria for nutrients as part of their water quality standards. EPA has developed nutrient criteria recommendations that are numeric values for both causative (phosphorus and nitrogen) and response (chlorophyll *a* and turbidity) variables associated with the prevention and assessment of eutrophic conditions. EPA's recommended nutrient criteria are different from most of its other recommended criteria, such as the criteria for cadmium and ammonia. First, EPA's recommended nutrient criteria are *ecoregional* rather than nationally applicable criteria, and they can be refined and localized using nutrient criteria technical guidance manuals. Second, the recommended nutrient criteria represent conditions of surface waters that have minimal impacts caused by human activities rather than values derived from laboratory toxicity testing. Third, the recommended nutrient criteria are do not include specific duration or frequency components; however, the ecoregional nutrient criteria documents indicate that states may adopt seasonal or annual averaging periods for nutrient criteria instead of the 1-hour, 24-hour, or 4-day average durations typical of aquatic life criteria for toxic pollutants. The ecoregional nutrient criteria documents, technical guidance manuals, and other information on EPA's nutrient criteria recommendations, are available on the Water Quality Criteria for Nitrogen and Phosphorus Pollution Website <www.epa.gov/waterscience/criteria/nutrient/>.

Water quality standards also typically include aquatic life criteria for parameters such as temperature and pH that are not chemical constituents. Criteria for pH generally are expressed as an acceptable pH range in the waterbody. Temperature criteria might be expressed as both *absolute temperature values* (e.g., temperature may not exceed 18 degrees Celsius [°C]) and restrictions on causing *changes in temperature* in the waterbody (e.g., discharges may not warm receiving waters by more than 0.5 °C).

In addition to criteria for individual pollutants or pollutant parameters, many states include in their water quality standards criteria for dissolved oxygen. Often, criteria for dissolved oxygen are addressed by modeling and limiting discharges of oxygen-demanding pollutants such as biochemical oxygen demand (BOD), chemical oxygen demand (COD), and nutrients (phosphorus and nitrogen).

Finally, states could also include in their water quality standards numeric criteria to address the effect of mixtures of pollutants. For example, whole effluent toxicity (WET) criteria protect the waterbody from the aggregate and synergistic toxic effects of a mixture of pollutants. WET is discussed in detail later in this chapter.

Numeric Criteria—Human Health

Human health criteria for toxic pollutants are designed to protect people from exposure resulting from consumption of fish or other aquatic organisms (e.g., mussels, crayfish) or from consumption of both water and aquatic organisms. These criteria express the highest concentrations of a pollutant that are not expected to pose significant long-term risk to human health. Exhibit 6-4 is an example of human health criteria for dichlorobromomethane.

Exhibit 6-4 Human health criteria example: Dichlorobromomethane

For the protection of human health from the potential carcinogenic effects of dichlorobromomethane through ingestion of water and contaminated aquatic organisms, the ambient water criterion is determined to be 0.55 µg/L. For the protection of human health from the potential carcinogenic effects of dichlorobromomethane through ingestion contaminated aquatic organisms alone, the ambient water criterion is determined to be 17 µg/L. These values were calculated based on a national default freshwater/estuarine fish consumption rate of 17.5 grams per day.

Other criteria for protection of human health (e.g., bacteria criteria) consider a shorter-term exposure through uses of the waterbody such as contact recreation. EPA's current bacteria criteria recommendations use enterococci and *Escherichia coli* bacteria as indicators and include two components: a geometric mean value and a single sample maximum value. EPA has developed information on implementing those criteria in water quality standards on the Microbial (Pathogen) Water Quality Criteria Website <www.epa.gov/waterscience/criteria/humanhealth/microbial/>.

Other Numeric Criteria

In addition to aquatic life and human health criteria, some state water quality standards include other forms of numeric criteria, such as wildlife, sediment, and biocriteria.

Wildlife criteria are derived to establish ambient concentrations of chemicals that, if not exceeded, will protect mammals and birds from adverse impacts resulting from exposure to those chemicals through consumption of aquatic organisms and water. EPA established four numeric criteria to protect wildlife in the Great Lakes system in its *Final Water Quality Guidance for the Great Lakes System* <www.epa.gov/EPA-WATER/1995/March/Day-23/pr-82.html> (60 FR 15387, March 23, 1995).

In a healthy aquatic community, sediments provide a habitat for many living organisms. Controlling the concentration of pollutants in the sediment helps to protect bottom-dwelling species and prevents harmful toxins from moving up the food chain and accumulating in the tissue of animals at progressively higher levels. For more information on this topic, see EPA's Suspended and Bedded Sediments Website <http://www.epa.gov/waterscience/criteria/sediment/>.

The presence, condition and numbers of types of fish, insects, algae, plants, and other organisms are data that, together, provide direct, accurate information about the health of specific bodies of water. Biological criteria (biocriteria) are narrative or numeric expressions that describe the reference biological integrity (structure and function) of aquatic communities inhabiting waters of a given designated aquatic life use. Biocriteria are based on the numbers and kinds of organisms present and are regulatory-based biological measurements. They are used as a way of describing the qualities that must be present to support a desired condition in a waterbody, and they serve as the standard against which biological assessment results are compared. EPA's Biocriteria: Uses of Data in NPDES Permits Website <http://www.epa.gov/waterscience/biocriteria/watershed/npdes.html> provides more information on the use of bioassessment information.

Narrative Criteria

All states have adopted narrative water quality criteria to supplement numeric criteria. Narrative criteria are statements that describe the desired water quality goal for a waterbody. Narrative criteria, for example, might require that discharges be "free from toxics in toxic amounts" or be "free of objectionable color, odor, taste, and turbidity." Narrative criteria can be the basis for limiting specific pollutants for which the state does not have numeric criteria [§ 122.44(d)(1)(vi)] or they can be used as the basis for limiting toxicity using WET requirements where the toxicity has not yet been traced to a specific pollutant or pollutants [§ 122.44(d)(1)(v)]. For toxic pollutants, EPA's Water Quality Standards Regulation at § 131.11(a)(2) requires states to develop implementation procedures for toxics narrative criteria that address how the state intends to regulate point source discharges of toxic pollutants to water quality limited segments.

6.1.1.3 Antidegradation Policy (§ 131.12)

The third part of a state's water quality standards is its antidegradation policy. Each state is required to adopt an antidegradation policy consistent with EPA's antidegradation regulations at § 131.12 A state's antidegradation policy specifies the framework to be used in making decisions about proposed activities that will result in changes in water quality. Antidegradation policies can play a critical role in helping states protect the public resource of water whose quality is better than established criteria levels and ensure that decisions to allow reductions in water quality are made in a public manner and serve the public good. Along with developing an antidegradation policy, each state must identify the method it will use to implement the policy. It is important for permit writers to be familiar with their state's antidegradation policy and how that policy is to be implemented in NPDES permits.

A state's antidegradation policy provides three levels of protection from degradation of existing water quality:

- **Tier 1:** This tier requires that existing uses, and the level of water quality necessary to protect the existing uses, be maintained and protected.
- **Tier 2:** Where the quality of waters exceeds levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water (sometimes referred to as *high-quality waters*), Tier 2 requires that this level of water quality be maintained and protected unless the state finds, after full satisfaction of the intergovernmental coordination and public participation provisions of the state's continuing planning process, that allowing lower water quality is necessary to accommodate important economic or social development in the area where the waters are located. In allowing any such degradation or lower water quality, the state must assure water quality adequate to protect existing uses fully and must assure that there will be achieved the highest statutory and regulatory requirements for all new and existing point sources and all cost-effective and reasonable best management practices for nonpoint source control.
- **Tier 3:** This tier requires that the water quality of outstanding national resources waters (ONRWs) be maintained and protected.

States take a variety of approaches to implementing antidegradation policies. Some states designate their waters as Tier 1, Tier 2 (high-quality water) or Tier 3 waters in their antidegradation implementation methods, while others designate a waterbody as a Tier 2 or high-quality water only when activities that would degrade water quality are proposed. In some cases, states may have classified the waterbody as receiving a tier of protection for all pollutant-related parameters, whereas in other cases, tiers of protection have been determined on a parameter-by-parameter basis.

6.1.1.4 General Policies (§ 131.13)

In addition to the three required components of water quality standards, states may, at their discretion, include in their standards policies that generally affect how the standards are applied or implemented. Examples of such policies include mixing zone policies, critical low flows at which criteria must be achieved, and the availability of variances. Some general policies are discussed in more detail later in this chapter. As with the other components of water quality standards, general policies are subject to EPA review and approval if they are deemed to be new or revised water quality standards (i.e., if they constitute a change to designated use(s), water quality criteria, antidegradation requirements, or any combination).

Additional and more detailed information on water quality standards is available in the WQS Handbook.

6.1.2 Water Quality Standards Modifications

Permit writers should be aware of several types of modifications to water quality standards that could permanently or temporarily change the standards and, thus, change the fundamental basis of WQBELs. Those modifications, described below, are as follows:

- Designated use reclassification.
- Site-specific water quality criteria modification.
- Water quality standard variance.

6.1.2.1 Designated Use Reclassification

Once a use has been designated for a particular waterbody or segment, that use may not be removed from the water quality standards except under specific conditions. To remove a designated use, the state demonstrates that attaining that use is not feasible because of any one of the six factors listed in § 131.10(g). The regulations at § 131.10(j) specifically require a state to conduct a UAA if the designated uses for a waterbody do not include the uses in CWA section 101(a)(2) (i.e., fishable/swimmable uses); if the state wishes to remove designated uses included in CWA section 101(a)(2) from its water quality standards; or if the state wishes to adopt subcategories of CWA section 101(a)(2) uses with less stringent criteria. The WQS Handbook discusses UAAs and removing designated uses in detail. Reclassifying a waterbody's designated uses, as supported by a UAA, is a permanent change to both the designated use(s) and the water quality criteria associated with that (those) use(s).

States may conduct a UAA and remove a designated use but not if it is an existing use. Existing uses are defined in § 131.3 as those uses actually attained in the waterbody on or after November 28, 1975 (the date of EPA's initial water quality standards regulation at 40 *Federal Register* 55334, November 28, 1975). At a minimum, uses are deemed attainable if they can be achieved by the implementing effluent limits required under CWA sections 301(b) and 306 and by implementing cost effective and reasonable best management practices (BMPs) for nonpoint source control. EPA's Water Quality Standards: UAA Website <http://www.epa.gov/waterscience/standards/uses/uaa/index.htm> provides additional information and some example UAAs.

6.1.2.2 Site-Specific Water Quality Criteria Modification

As noted above, CWA sections 303(a)–(c) require states to adopt water quality criteria sufficient to protect applicable designated uses. In some cases, a state might find that the criteria it has adopted to protect a waterbody or segment of a waterbody do not adequately account for site-specific conditions. In such cases, states have the option of modifying water quality criteria on a site-specific basis. Setting site-specific criteria might be appropriate where, for example, a state has adopted EPA's CWA section 304(a) criteria recommendations and finds that physical or chemical properties of the water at a site affect the bioavailability or toxicity of a chemical, or the types of local aquatic organisms differ significantly from those actually tested in developing the EPA-recommended criteria. Site-specific criteria modifications change water quality criteria permanently while continuing to support the current designated uses.

Development of site-specific criteria for aquatic life is discussed in section 3.7 of the WQS Handbook for cases when (1) there might be relevant differences in the toxicity of the chemical in the water at the site and laboratory dilution water (Water-Effect Ratio Procedure) and (2). the species at the site are more or less sensitive than those used in developing the natural criteria (Species Recalculation Procedure). EPA's Office of Science and Technology (OST) has developed the Interim Guidance on Determination and Use of Water-Effect Ratios for Metals <www.epa.gov/waterscience/standards/handbook/handbookappxL.pdf> in Appendix L of the WQS Handbook and the *Streamlined Water-Effect Ratio Procedure for Discharges of Copper*[2] <www.epa.gov/waterscience/criteria/copper/copper.pdf>. In addition, pages 90-97 of Appendix L provide guidance for using the Species Recalculation Procedure. States may also consider establishing aquatic life criteria based on *natural background* conditions. Further information can be found in the memo *Establishing Site Specific Aquatic Life Criteria Equal to Natural Background*[3] <www.epa.gov/waterscience/library/wqcriteria/naturalback.pdf>.

6.1.2.3 Water Quality Standard Variance

Water quality standard variances are changes to water quality standards and have similar substantive and procedural requirements and what is required to remove a designated use. Unlike use removal, variances are time-limited and do not permanently remove the current designated use of a waterbody. Variances are usually discharger- and pollutant-specific, though some states have adopted *general variances*. Where a state has adopted a general variance, the analyses necessary for the variance have been completed on a watershed-wide or statewide basis and, therefore, the process of obtaining a variance is simplified for individual dischargers in that watershed or state.

A variance might be appropriate where the state believes that the existing standards are ultimately attainable and that, by retaining the existing standards rather than changing them, the state would ensure that further progress is made in improving the water quality toward attaining the designated uses while the variance is in effect. State-adopted variances have been approved by EPA where, among other things, the state's standards allow variances and the state demonstrates that meeting the applicable criteria is not feasible on the basis of one or more of the factors outlined in § 131.10(g). A variance typically is granted for a specified period and must be reevaluated at least once every 3 years as reasonable progress is made toward meeting the standards [see section 5.3 of the WQS Handbook and § 131.20(a)].

Modifications of water quality standards could affect effluent limitations in permits in several ways. Specifically, the modifications can change the fundamental basis for WQBELs, potentially affecting an assessment of the need for WQBELs and possibly resulting in either more or less stringent WQBELs than would otherwise be required. It is the permit writer's responsibility to ensure that any EPA-approved modification of water quality standards is properly reflected in an affected NPDES permit.

6.1.3 Water Quality Standards Implementation

As previously noted, CWA section 301(b)(1)(C) requires NPDES permits to establish effluent limitations as necessary to meet water quality standards. Effluent limitations and other conditions in NPDES permits may be based on a parameter-specific approach or a WET testing approach to implementing water quality standards. A third approach to implementing water quality standards, using biocriteria or bioassessment, is not directly accomplished through NPDES permit effluent limitations but can lead to effluent limitations for specific parameters or for WET. Each of those approaches to implementing water quality standards is discussed briefly below.

What procedures should permit writers use to implement water quality standards?

The terminology used and procedures described in this manual when discussing both assessing the need for and calculating WQBELs are based on the procedures in EPA's *Technical Support Document for Water Quality-Based Toxics Control*[4] <www.epa.gov/npdes/pubs/owm0264.pdf> (hereafter *TSD*). Those procedures were developed specifically to address toxic pollutants but have been appropriately used to address a number of conventional and nonconventional pollutants as well. Permit writers should be aware that most permitting authorities have developed their own terminology and procedures for water quality-based permitting, often derived from, but with variations on, EPA's guidance. For example, EPA itself promulgated *Final Water Quality Guidance for the Great Lakes System* (60 FR 15387, March 23, 1995) with minimum water quality criteria, antidegradation policies, and implementation procedures, including permitting procedures based on the TSD. Under the CWA, Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin were required to adopt procedures for the Great Lakes system that are consistent with that guidance. Permit writers should always consult the applicable permitting regulations, policy, and guidance for the approved water quality-based permitting procedures in their state.

6.1.3.1 Parameter-Specific Approach

The parameter-specific approach uses parameter-specific criteria for protection of aquatic life, human health, wildlife, and sediments, as well as any other parameter-specific criteria adopted into a state's water quality standards. The criteria are the basis for analyzing an effluent, deciding which parameters need controls, and deriving effluent limitations that will control those parameters to the extent necessary to achieve water quality standards in the receiving water. Parameter-specific WQBELs in NPDES permits involve a site-specific evaluation of the discharge (or proposed discharge) and its potential effect on the receiving water or an evaluation of the effects of multiple sources of a pollutant on the receiving water (e.g., through a total maximum daily load [TMDL] analysis). The parameter-specific approach allows for controlling individual parameters, (e.g., copper, BOD, total phosphorus) before a water quality impact has occurred or for helping return water quality to a level that will meet designated uses.

6.1.3.2 Whole Effluent Toxicity (WET) Approach

WET requirements in NPDES permits protect aquatic life from the aggregate toxic effect of a mixture of pollutants in the effluent. WET tests measure the degree of response of exposed aquatic test organisms to an effluent. The WET approach is useful for complex effluents where it might be infeasible to identify and regulate all toxic pollutants in the effluent or where parameter-specific effluent limitations are set, but the combined effects of multiple pollutants are suspected to be problematic. The WET approach allows a permit writer to implement numeric criteria for toxicity included in a state's water quality standards or to be protective of a narrative "no toxics in toxic amounts" criterion. Like the parameter-specific approach, the WET approach allows permitting authorities to control toxicity in effluents before toxic impacts occur or may be used to help return water quality to a level that will meet designated uses.

6.1.3.3 Bioassessment Approach

The biocriteria approach is used to assess the overall biological integrity of an aquatic community. As discussed in section 6.1.1 above, biocriteria are numeric values or narrative statements that describe the biological integrity of aquatic communities inhabiting waters of a given designated aquatic life use. When incorporated into state water quality standards, biocriteria and aquatic life use designations serve as direct endpoints for determining aquatic life use attainment. Once biocriteria are developed, the biological condition of a waterbody can be measured through a biological assessment, or bioassessment.

A bioassessment is an evaluation of the biological condition of a waterbody using biological surveys and other direct measurements of resident biota in surface waters. A biological survey, or biosurvey, consists of collecting, processing, and analyzing representative portions of a resident aquatic community to determine the community structure and function. The results of biosurveys can be compared to the reference waterbody to determine if the biocriteria for the designated use of the waterbody are being met. EPA issued guidance on this approach in *Biological Criteria: National Program Guidance for Surface Waters*[5] <www.epa.gov/bioindicators/html/biolcont.html>. As previously discussed, biocriteria generally are not directly implemented through NPDES permits but could be used in assessing whether a waterbody is attaining water quality standards. Nonattainment of biocriteria could lead to parameter-specific effluent limitations where the permitting authority is able to identify specific pollutant(s) and source(s) contributing to that nonattainment (see EPA's Biocriteria: Uses of Data – Identify Stressors to a Waterbody Website <http://www.epa.gov/waterscience/biocriteria/uses/stressors.html> or could lead to WET limitations where the permitting authority identifies sources of toxicity to aquatic life. EPA's Biocriteria: Uses of Data - NPDES <http://www.epa.gov/waterscience/biocriteria/watershed/npdes.html> provides examples on the use of bioassessment information in the NPDES permitting process.

Sections 6.2–6.4 below discuss, in detail, implementing water quality standards using the parameter-specific approach to assess the need for and develop effluent limitations in NPDES permits. Section 6.5 below provides additional detail on WET requirements in NPDES permits.

6.2 Characterize the Effluent and the Receiving Water

After identifying the most current, approved, water quality standards that apply to a waterbody, a permit writer should characterize both the effluent discharged by the facility being permitted and the receiving water for that discharge. The permit writer uses the information from those characterizations to determine whether WQBELs are required (section 6.3 below) and, if so, to calculate WQBELs (section 6.4 below). Characterizing the effluent and receiving water can be divided into five steps as shown in Exhibit 6-5 and discussed in detail below.

Exhibit 6-5 Steps for characterizing the effluent and receiving water

Step 1.	Identify pollutants of concern in the effluent
Step 2.	Determine whether water quality standards provide for consideration of a dilution allowance or mixing zone
Step 3.	Select an approach to model effluent and receiving water interactions
Step 4.	Identify effluent and receiving water critical conditions
Step 5.	Establish an appropriate dilution allowance or mixing zone

6.2.1 Step 1: Identify Pollutants of Concern in the Effluent

There are several sources of information for and methods of identifying pollutants of concern for WQBEL development. For some pollutants of concern, the permit writer might not need to conduct any further analysis and could, after characterizing the effluent and receiving water, proceed directly to developing WQBELs (section 6.4 below). For other pollutants of concern, the permit writer uses the information from the effluent and receiving water characterization to assess the need for WQBELs (section 6.3 below). The following subsections identify five categories of pollutants of concern for WQBEL development.

6.2.1.1 Pollutants with Applicable TBELs

One category of pollutants of concern includes those pollutants for which the permit writer has developed TBELs based on national or state technology standards or on a case-by-case basis using best professional judgment. By developing TBELs for a pollutant, the permit writer has already determined that there will be some type of final limitations for that pollutant in the permit and must then determine whether more stringent limitations than the applicable TBELs are needed to prevent an excursion above water quality standards in the receiving water (see Exhibit 6-1 above). A permit writer can determine whether the TBELs are sufficiently protective by either proceeding to calculate WQBELs as described in section 6.4 below and comparing them to the TBELs or by assuming that the maximum daily TBEL calculated is the maximum discharge concentration in the water quality assessments described in section 6.3 below.

6.2.1.2 Pollutants with a Wasteload Allocation from a TMDL

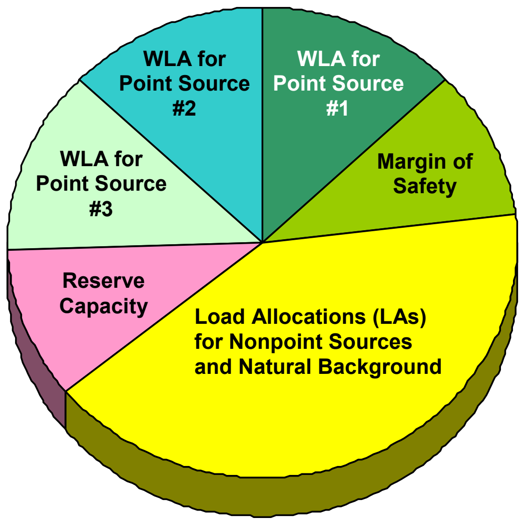
Pollutants of concern include those pollutants for which a *wasteload allocation* (WLA) has been assigned to the discharge through a TMDL. Under CWA section 303(d), states are required to develop lists of impaired waters. Impaired waters are those that do not meet the water quality standards set for them, even after point sources of pollution have installed the minimum required levels of pollution control technology. The law requires that those jurisdictions establish priority rankings for waters on their CWA section 303(d) list and develop TMDLs for those waters.

What is a WLA?

The term WLA refers to the portion of a receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution [see § 130.2(h)]. The WLA could be allocated through an EPA-approved TMDL, an EPA or state watershed loading analysis, or a facility-specific water quality modeling analysis.

A TMDL is a calculation of the maximum amount of a single pollutant that a waterbody can receive and still meet water quality standards and an allocation of that amount to the pollutant's sources. The portions of the TMDL assigned to point sources are WLAs, and the portions assigned to nonpoint sources and background concentrations of the pollutant are called *load allocations* (LAs). The calculation must include a margin of safety to ensure that the waterbody can be used for the purposes designated in the water quality standards, to provide for the uncertainty in predicting how well pollutant reduction will result in meeting water quality standards, and to account for seasonal variations. A TMDL might also include a reserve capacity to accommodate expanded or new discharges in the future. Exhibit 6-6 depicts the parts of a TMDL.

Exhibit 6-6 Parts of a TMDL



TMDL = ΣWLA + ΣLA + Margin of Safety + Reserve Capacity

The NPDES regulations at § 122.44(d)(1)(vii)(B) require that NPDES permits include effluent limitations developed consistent with the assumptions and requirements of any WLA that has been assigned to the discharge as part of an approved TMDL. Thus, any pollutant for which a WLA has been assigned to the permitted facility through a TMDL is a pollutant of concern.

Permit writers might also choose to consider any pollutant associated with an impairment of the receiving water a pollutant of concern, regardless of whether an approved TMDL has been developed for that pollutant, a WLA has been assigned to the permitted facility, or the permitted facility has demonstrated that the pollutant is present in its effluent. Permitting authorities might consider monitoring requirements to collect additional data related to the presence or absence of the impairing pollutant in a specific discharge to provide information for further analyses.

6.2.1.3 Pollutants Identified as Needing WQBELs in the Previous Permit

Another category of pollutants of concern includes those pollutants that were identified as needing WQBELs in the discharger's previous permit. Permit writers must determine whether the conditions leading to a decision to include WQBELs for the pollutant in the previous permit continue to apply. Where those conditions no longer apply, the permit writer would need to complete an anti-backsliding analysis to determine whether to remove the WQBELs from the reissued permit. Chapter 7 of this manual provides additional information on anti-backsliding requirements of the CWA and NPDES regulations. In addition, the permit writer might need to conduct an antidegradation analysis if the revised limitation would allow degradation of the quality of the receiving water.

6.2.1.4 Pollutants Identified as Present in the Effluent through Monitoring

Pollutants of concern also include any pollutants identified as present in the effluent through effluent monitoring. Effluent monitoring data are reported in the discharger's NPDES permit application, discharge monitoring reports and special studies. In addition, the permitting authority might collect data itself through compliance inspection monitoring or other special study. Permit writers can match information on which pollutants are present in the effluent to the applicable water quality standards to identify parameters that are candidates for WQBELs.

6.2.1.5 Pollutants Otherwise Expected to be Present in the Discharge

A final category of pollutants of concern includes those pollutants that are not in one of the other categories but are otherwise expected to be present in the discharge. There might be pollutants for which neither the discharger nor the permitting authority have monitoring data but, because of the raw materials stored or used, products or by-products of the facility operation, or available data and information on similar facilities, the permit writer has a strong basis for expecting that the pollutant could be present in the discharge. Because there are no analytical data to verify the concentrations of these pollutants in the effluent, the permit writer must either postpone a quantitative analysis of the need for WQBELs and generate, or require the discharger to generate, effluent monitoring data, or base a determination of the need for WQBELs on other information, such as the effluent characteristics of a similar discharge. A discussion on determining the need for WQBELs without effluent monitoring data is provided in section 6.3.3 below.

6.2.2 Step 2: Determine Whether Water Quality Standards Provide for Consideration of a Dilution Allowance or Mixing Zone

Many state water quality standards have general provisions allowing some consideration of mixing of effluent and receiving water when determining the need for and calculating WQBELs. Depending on the state's water quality standards and implementation policy, such a mixing consideration could be expressed in the form of a *dilution allowance* or *regulatory mixing zone*. A dilution allowance typically is expressed as the flow of a river or stream, or a portion thereof. A regulatory mixing zone generally is expressed as a limited area or volume of water in any type of waterbody where initial dilution of a discharge takes place and within which the water quality standards allow certain water quality criteria to be exceeded. Section 6.2.5 below discusses dilution allowances and mixing zones in greater detail.

State water quality standards or implementation policies might indicate specific locations or conditions (e.g., breeding grounds for aquatic species or bathing beaches) or water quality criteria (e.g., pathogens, pH, bioaccumulative pollutants, or narrative criteria) for which consideration of a dilution allowance or mixing zone is not allowed or is otherwise considered inappropriate.

6.2.3 Step 3: Select an Approach to Model Effluent and Receiving Water Interactions

Where consideration of a dilution allowance or mixing zone is not permitted by the water quality standards or is not appropriate, the relevant water quality criterion must be attained at the point of discharge. In such cases, there is no need for a water quality model to characterize the interaction between the effluent and receiving water. In this situation effluent limitations are based on attaining water quality criteria at the "end of the pipe."

Where a dilution allowance or mixing zone is permitted, however, characterizing the interaction between the effluent and receiving water generally requires using a water quality model. In the majority of situations, and in all of the examples provided in this manual, permit writers will use a steady-state water quality model to assess the impact of a discharge on its receiving water. Steady-state means that the model projects the impact of the effluent on the receiving water under a single or *steady* set of design conditions. Because the model is run under a single set of conditions, those conditions generally are set at *critical conditions* for protection of receiving water quality as discussed in section 6.2.4 below. The permit writer would determine the amount of the dilution allowance or the size of the mixing zone that is available under these critical conditions as provided in section 6.2.5 below.

6.2.4 Step 4: Identify Effluent and Receiving Water Critical Conditions

Where steady-state models are used for water quality-based permitting, an important part of characterizing the effluent and receiving water is identifying the critical conditions needed as inputs to the water quality model. Permit writers should discuss selection of critical conditions with water quality modelers or other water quality specialists. Identifying the right critical conditions is important for appropriately applying a water quality model to assess the need for WQBELs and to calculate WQBELs. Some key effluent and receiving water critical conditions are summarized below.

What if I am not a water quality modeler?

Permit writers are not always water quality modelers, nor do they necessarily need to be experts in this field. Many permitting authorities have a team of water quality specialists who model point source discharges to provide data required for permit writers to assess the need for and develop WQBELs. In some cases, this team might even calculate WQBELs directly for the permit writers, who then only need to compare them to TBELs and determine the final effluent limitations for the NPDES permit. Permit writers should, at a minimum, familiarize themselves with water quality modeling concepts presented in this manual, particularly the identification of critical conditions input to a steady-state water quality model, and should consult water quality modelers or other water quality specialists as needed in the process of NPDES permit development.

6.2.4.1 Effluent Critical Conditions

In most any steady-state water quality model there will be at least two basic critical conditions related to the effluent: flow and pollutant concentration.

Effluent Flow

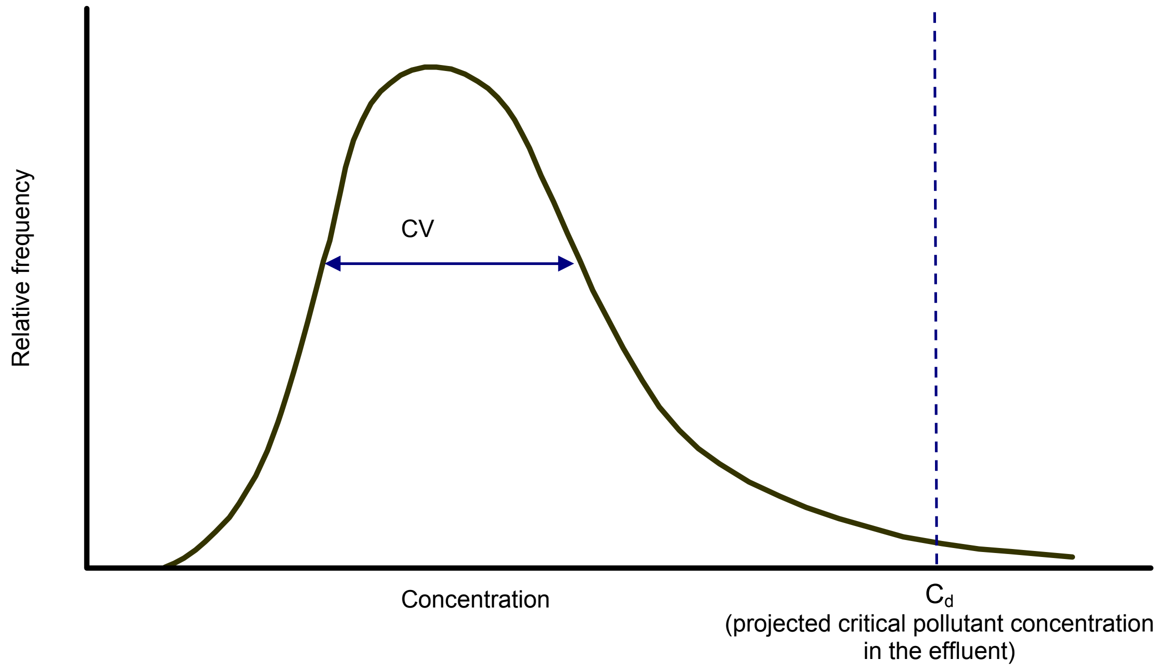
Effluent flow (designated Q_d in the water quality modeling equations used in this manual) is a critical design condition used when modeling the impact of an effluent discharge on its receiving water. A permit writer should be able to obtain effluent flow data from discharge monitoring reports or a permit application. Permitting authority policy or procedures might specify which flow measurement to use as the critical effluent flow value(s) in various water quality-based permitting calculations (e.g., the maximum daily flow reported on the permit application, the maximum of the monthly average flows from discharge monitoring reports for the past three years, the facility design flow). Permit writers should follow existing policy or procedures for determining critical effluent flow or, if the permitting authority does not specify how to determine this value, look at past permitting practices and strive for consistency.

Effluent Pollutant Concentration

Permit writers can determine the critical effluent concentration of the pollutant of concern (designated C_d) by gathering effluent data representative of the discharge. To establish the critical effluent pollutant concentration from the available data, EPA has recommended considering a concentration that represents something close to the maximum concentration of the pollutant that would be expected over time. In most cases, permit writers have a limited effluent data set and, therefore, would not have a high degree of certainty that the limited data would actually include the maximum potential effluent concentration of the pollutant of concern. In addition, the NPDES regulations at § 122.44(d)(1)(ii) require that permit writers consider the variability of the pollutant in the effluent when determining the need for WQBELs. To address those concerns, EPA developed guidance for permit writers on how to characterize effluent concentrations of certain types of pollutants using a limited data set and accounting for variability. This guidance is detailed in EPA's TSD.

By studying effluent data for numerous facilities, EPA determined that daily pollutant measurements of many pollutants follow a *lognormal distribution*. The TSD procedures allow permit writers to project a critical effluent concentration (e.g., the 99th or 95th percentile of a lognormal distribution of effluent concentrations) from a limited data set using statistical procedures based on the characteristics of the lognormal distribution. These procedures use the number of available effluent data points for the measured concentration of the pollutant and the coefficient of variation (or CV) of the data set, which is a measure of the variability of data around the average, to predict the critical pollutant concentration in the effluent. Exhibit 6-7 provides an example of a lognormal distribution of effluent pollutant concentrations and projection of a critical effluent pollutant concentration (C_d). For additional details regarding EPA's guidance, see Chapter 3 of the TSD. Many permitting authorities have developed procedures for estimating a critical effluent pollutant concentration that are based on or derived from those procedures. For pollutants with effluent concentrations that *do not* follow a lognormal distribution, permit writers would rely on alternative procedures developed by their permitting authority for determining the critical effluent pollutant concentration.

Exhibit 6-7 Example of lognormal distribution of effluent pollutant concentrations and projection of critical concentration (C_d)



6.2.4.2 Receiving Water Critical Conditions

As with the effluent, flow (for rivers and streams) and pollutant concentration are receiving water critical conditions used in steady-state water quality models. In addition, depending on the waterbody and pollutant of concern, there could be additional receiving water characteristics that permit writers need to consider in a water quality model.

Receiving Water Upstream Flow

For rivers and streams, an important critical condition is the stream flow upstream of the discharge (designated Q_s). That critical condition generally is specified in the applicable water quality standards and reflects the duration and frequency components of the water quality criterion that is being addressed. For most pollutants and criteria, the critical flow in rivers and streams is some measure of the low flow of that river or stream; however, the critical condition could be different (for example, a high flow, where wet weather sources are a major problem). If a discharge is controlled so that it does not cause water quality criteria to be exceeded in the receiving water at the critical flow condition, the discharge controls should be protective and ensure that water quality criteria, and thus designated uses, are attained under all receiving water flow conditions.

Examples of typical critical hydrologically based low flows found in water quality standards include the 7Q10 (7-day average, once in 10 years) low flow for chronic aquatic life criteria, the 1Q10 low flow for acute aquatic life criteria, and the harmonic mean flow for human health criteria for toxic organic pollutants. The permit writer might examine stream flow data from the state or the U.S. Geological

Survey to determine the critical flow at a point upstream of the discharge. The permit writer might also account for any additional sources of flow or diversions between the point where a critical low flow has been calculated and the point of discharge. EPA also has developed a biologically based flow method that directly uses the durations and frequencies specified in the water quality criteria.

Climate Change Considerations

As noted in this section, the receiving water upstream flow is an important factor in modeling the interaction between the effluent discharge and a river or stream. In most instances, state water quality standards or implementation policies establish the critical low flows that should be used in modeling this interaction. The most common source of upstream flow data for water quality modelers is historical flow gage data available through the U.S. Geological Survey. Modelers should be aware that the effects of climate change could alter historical flow patterns in rivers and streams, making these historical flow records less accurate in predicting current and future critical flows. Where appropriate, water quality modelers should consider alternate approaches to establishing critical low flow conditions that account for these climatic changes.

Receiving Water Background Pollutant Concentration

In addition to determining the critical effluent concentration of the pollutant of concern, the permit writer also should determine the critical background concentration of the pollutant of concern in the receiving water before the discharge (designated C_S) to ensure that any pollutant limitations derived are protective of the designated uses. Permitting authority policies or procedures often address how to determine that critical background concentration value for the pollutant. For example, using ambient data or working with the discharger to obtain reliable ambient data, the permit writer might use the maximum measured background pollutant concentration or, perhaps, an average of measured concentrations as the critical condition. Ambient data will provide the most reliable characterization of receiving water background pollutant concentration. EPA encourages permitting authorities to collect and use actual ambient data, where possible. Where data are not available, however, the state might have other procedures, such as establishing that without valid and representative ambient data, no dilution or mixing will be allowed (i.e., criteria end-of-pipe), or using a percentage of an applicable water quality criterion or a detection, quantitation, or other reporting level. The permit writer should consult the permitting authority's policies and procedures or, if there are no policies or procedures available, look at past permitting practices and maintain consistency with those practices when determining the critical receiving water background concentrations.

Other Receiving Water Characteristics

For waterbodies other than free-flowing rivers and streams, there might be critical environmental conditions that apply rather than flow (e.g., tidal flux, temperature). In addition, depending on the pollutant of concern, the effects of biological activity and reaction chemistry might be important in assessing the impact of a discharge on the receiving water. In such situations, additional critical receiving water conditions that might be used in a steady-state water quality model include conditions such as pH, temperature, hardness, or reaction rates, and the presence or absence of certain fish species or life stages of aquatic organisms, to name a few.

Sections 6.3 and 6.4 below provide further discussion of how critical conditions are applied in a water quality model to determine the need for and calculate WQBELs.

6.2.5 Step 5: Establish an Appropriate Dilution Allowance or Mixing Zone

Following verification of whether the applicable water quality standards allow any consideration of effluent and receiving water mixing and, for a steady-state modeling approach, the critical conditions that apply to the effluent and receiving water, permit writers can determine how the effluent and the receiving water mix under critical conditions. Based on this determination, permit writers can then establish the maximum dilution allowance or mixing zone allowed by the water quality standards for each pollutant of concern.

6.2.5.1 Type of Mixing Under Critical Conditions

On the basis of requirements in the water quality standards, the dilution allowance or mixing zone used in water quality models and calculations are likely to vary depending on whether there is rapid and complete mixing or incomplete mixing of the effluent and receiving water under critical conditions. Thus, the permit writer needs to understand something about *how* the effluent and receiving water mix under critical conditions.

Rapid and complete mixing is mixing that occurs when the lateral variation in the concentration of a pollutant in the direct vicinity of the outfall is small. The applicable water quality standards might specify certain conditions under which a permit writer could *assume* that rapid and complete mixing is occurring, such as the presence of a diffuser. Some standards may also allow a *demonstration* of rapid and complete mixing in cases where the conditions for simply assuming rapid and complete mixing are not met. For example, the applicable water quality standards might specify a distance downstream of a discharge point by which the pollutant concentration across the stream width must vary by less than a certain percentage to assume that there is rapid and complete mixing.

If the permit writer cannot assume rapid and complete mixing and there has been no demonstration of rapid and complete mixing, the permit writer should assume that there is incomplete mixing. Under incomplete mix conditions, mixing occurs more slowly and higher concentrations of pollutants are present in-stream near the discharge as compared to rapid and complete mixing. Thus, an assumption of incomplete mixing is more conservative than an assumption of rapid and complete mixing. For waterbodies other than rivers and streams (e.g., lakes, bays, and the open ocean) the permit writer usually would assume incomplete mixing.

6.2.5.2 Maximum Dilution Allowance or Mixing Zone Size

Once a permit writer determines whether the applicable water quality standards allows consideration of some ambient dilution or mixing and determines the type of mixing taking place (rapid and complete mixing versus incomplete mixing), he or she would again consult the water quality standards to determine the maximum size of the dilution allowance or mixing zone that may be considered in water quality modeling calculations.

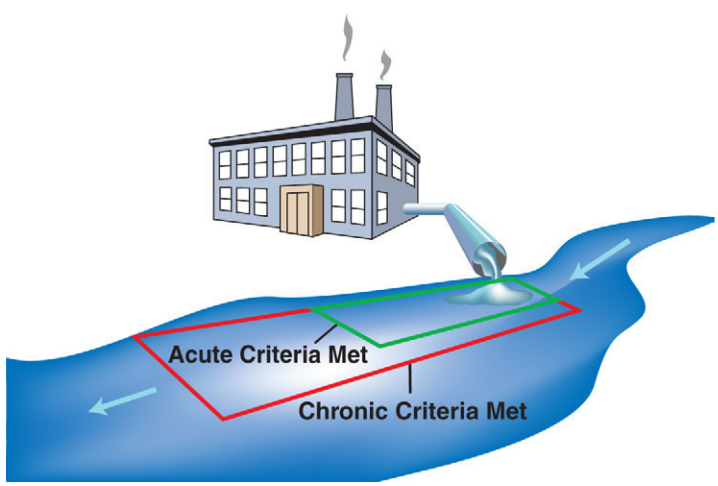
Dilution Allowances in Rapid and Complete Mix Situations

The maximum permissible dilution allowance for rivers and streams under conditions of rapid and complete mixing should be indicated in the water quality standards or standards implementation policy. For example, some water quality standards allow a permit writer to use up to 100 percent of the critical low flow of a river or stream as a dilution allowance in water quality models and calculations when there is rapid and complete mixing. In some cases, water quality standards implement a factor of safety by permitting only a percentage of the critical low flow to be used as a dilution allowance, even when there is rapid and complete mixing under critical conditions. Water quality standards might incorporate such a factor of safety to account for any uncertainty related to other conditions in the waterbody or to ensure that some assimilative capacity is retained downstream of the discharge being permitted. Recall as well that for some pollutants (e.g., pathogens in waters designated for primary contact recreation, bioaccumulative pollutants), the water quality standards or implementing procedures might not authorize any dilution allowance even where the effluent and receiving water mix rapidly and completely.

Dilution Allowances and Regulatory Mixing Zones in Incomplete Mix Situations

In an incomplete mixing situation, the water quality standards or implementation policies might allow some consideration of ambient dilution. Rather than permitting as much as 100 percent of the critical low flow as a dilution allowance, however, they will likely specify either a limited dilution allowance (such as a percentage of the critical low flow) or the maximum size of a regulatory mixing zone. A regulatory *mixing zone* is a limited area or volume of water where initial dilution of a discharge takes place and within which the water quality standards allow certain water quality criteria to be exceeded. While the criteria may be exceeded within the mixing zone, the use and size of the mixing zone must be limited such that the waterbody as a whole will not be impaired and such that all designated uses are maintained as discussed in section 6.2.5.3 below. Exhibit 6-8 is a diagram illustrating the concept of a regulatory mixing zone. The mixing zone often is a simple geometric shape inside of which a water quality criterion may be exceeded. The geometric shape does not characterize how mixing actually occurs. Actual mixing is described using field studies and a water quality model.

Exhibit 6-8 Regulatory mixing zones for aquatic life criteria



Note that Exhibit 6-8 above illustrates two different mixing zones, one for an acute aquatic life criterion and one for a chronic aquatic life criterion. The water quality standards could specify different maximum mixing zones sizes for different pollutants, different types of criteria, and different waterbody types. Exhibit 6-9 provides examples of different maximum mixing zone sizes and dilution allowances.

Exhibit 6-9 Examples of maximum mixing zone sizes or dilution allowances under incomplete mixing conditions by waterbody type*

For rivers and streams:
- Mixing zones cannot be larger than 1/4 of the stream width and 1/4 mile downstream
- Mixing must be less than 1/2 stream width with a longitudinal limit of 5 times the stream width
- Dilution cannot be greater than 1/3 of the critical low flow

For lakes and the ocean:
- Mixing zones for lakes cannot be larger than 5% of the lake surface
- A maximum of 4:1 dilution is available for lake discharges
- A maximum of 10:1 dilution is available for ocean discharges
- The maximum size mixing zone for the ocean is a 100-foot radius from the point of discharge

* Examples were adapted from state standards and procedures and do not reflect EPA guidance or recommendations.

Permit writers should always check the applicable water quality standards to see if mixing zones are permitted and determine the maximum mixing zone size for the waterbody type, pollutant of concern, and specific criterion being considered.

6.2.5.3 Restrictions on Dilution Allowance or Mixing Zone Size

In addition to specifying the maximum dilution allowance or mixing zone size allowed under both rapid and complete mixing conditions and incomplete mixing conditions, the water quality standards or implementation policies generally include constraints that could further limit the available dilution allowance or mixing zone size to something less than the absolute maximum allowed. For example, one restriction on the size of the acute mixing zone could be that it must be small enough to ensure that the potential time of exposure of aquatic organisms to a pollutant concentration above the acute criterion is very short, and organisms passing through that acute mixing zone will not die from exposure to the pollutant. Such a restriction might lead the permitting authority to give a discharger an acute mixing zone for a specific pollutant that is smaller than the maximum size allowed by the water quality standards or to not allow any acute mixing zone at all. Other possible restrictions on dilution and mixing zone size include preventing impairment of the integrity of the waterbody as a whole and preventing significant risks to human health. For example, a permitting authority might restrict the size of a mixing zone for a human health criterion to prevent the mixing zone from overlapping a drinking water intake.

6.3 Determine the Need for WQBELs

After determining the applicable water quality standards and characterizing the effluent and receiving water, a permit writer determines whether WQBELs are needed. This section provides an overview of that process.

6.3.1 Defining Reasonable Potential

EPA regulations at § 122.44(d)(1)(i) state, "Limitations must control all pollutants or pollutant parameters (either conventional, nonconventional, or toxic pollutants) which the Director determines are or may be discharged at a level that will *cause*, have the *reasonable potential to cause*, or *contribute* to an excursion above any [s]tate water quality standard, including [s]tate narrative criteria for water quality." [emphasis added] Because of that regulation, EPA and many authorized NPDES states refer to the process that a permit writer uses to determine whether a WQBEL is required in an NPDES permit as a *reasonable potential analysis*. Wording the requirements of the regulation another way, a reasonable potential analysis is used to determine whether a discharge, alone or in combination with other sources of pollutants to a waterbody and under a set of conditions arrived at by making a series of reasonable assumptions, could lead to an excursion above an applicable water quality standard. The regulation also specifies that the reasonable potential determination must apply not only to numeric criteria, but also to narrative criteria (e.g., *no toxics in toxic amounts*, *presence of pollutants or pollutant parameters in amounts that would result in nuisance algal blooms*). A permit writer can conduct a reasonable potential analysis using effluent and receiving water data and modeling techniques, as described above, or using a non-quantitative approach. Both approaches are discussed below.

6.3.2 Conducting a Reasonable Potential Analysis Using Data

When determining the need for a WQBEL, a permit writer should use any available effluent and receiving water data as well as other information pertaining to the discharge and receiving water (e.g., type of industry, existing TBELs, compliance history, stream surveys), as the basis for a decision. The permit writer might already have data available from previous monitoring or he or she could decide to work with the permittee to generate data before permit issuance or as a condition of the new permit. EPA recommends that monitoring data be generated before effluent limitation development whenever possible. Monitoring should begin far enough in advance of permit development to allow sufficient time to conduct chemical analyses. Where data are generated as a condition of the permit (for example for a new permittee), it might be appropriate for the permit writer to include a reopener condition in the permit to allow the incorporation of a WQBEL if the monitoring data indicate that a WQBEL is required.

A reasonable potential analysis conducted with available data can be divided into four steps as shown in Exhibit 6-10 and discussed in detail below.

Exhibit 6-10 Steps of a reasonable potential analysis with available data

Step 1.	Determine the appropriate water quality model
Step 2.	Determine the expected receiving water concentration under critical conditions
Step 3.	Answer the question, "Is there reasonable potential?"
Step 4.	Document the reasonable potential determination in the fact sheet

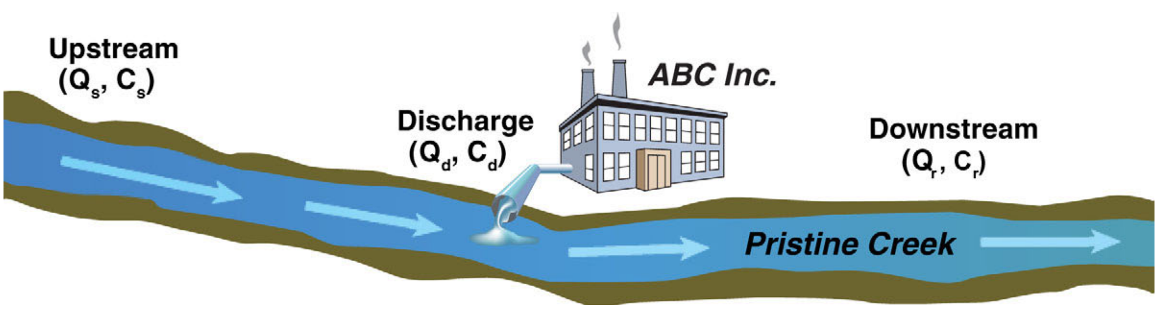
6.3.2.1 Step 1: Determine the Appropriate Water Quality Model

Steady-state or dynamic water quality modeling techniques can be used in NPDES permitting. As discussed in section 6.2.3 above, the examples in this manual consider only steady-state modeling techniques, which consider the impact of a discharge on the receiving water modeled under a single set of critical conditions.

The specific steady-state model used will depend on the pollutant or parameter of concern and whether there is rapid and complete mixing or incomplete mixing of the effluent and the receiving water under critical conditions. For example, to model dissolved oxygen in a river, the permit writer might choose the Streeter-Phelps equation. For modeling heavy metals in an incomplete mix situation, the permit writer might choose the CORMIX model. For pollutants such as BOD, nutrients, or non-conservative parameters, the effects of biological activity and reaction chemistry should be modeled, in addition to the effects of dilution, to assess possible impacts on the receiving water. This manual focuses only on dilution of a pollutant discharged to the receiving water and does not address modeling biological activity or reaction chemistry in receiving waters. For additional information, permit writers should discuss modeling that accounts for biological activity or reaction chemistry with water quality modelers or other water quality specialists as needed and consult EPA's Water Quality Models and Tools Website <www.epa.gov/waterscience/models/>.

For many pollutants such as most toxic (priority) pollutants, conservative pollutants, and pollutants that can be treated as conservative pollutants when near-field effects are of concern, if there is rapid and complete mixing in a river or stream, the permit writer could use a simple mass-balance equation to model the effluent and receiving water. The simple mass-balance equation as applied to a hypothetical facility, ABC, Inc., discharging Pollutant Z to a free-flowing stream called Pristine Creek is presented in Exhibit 6-11 below.

Exhibit 6-11 Simple mass-balance equation



Mass	=	**Flow** (Q) in million gallons per day (mgd) or cubic feet per second (cfs)	X	**Pollutant concentration** (C) in milligrams per liter (mg/L)

$$Q_s C_s + Q_d C_d = Q_r C_r$$

where

Q_s	=	stream flow in mgd or cfs above point of discharge
C_s	=	background in-stream pollutant concentration in mg/L
Q_d	=	effluent flow in mgd or cfs
C_d	=	effluent pollutant concentration in mg/L
Q_r	=	resultant in-stream flow, after discharge in mgd or cfs
C_r	=	resultant in-stream pollutant concentration in mg/L (after complete mixing occurs)

6.3.2.2 Step 2: Determine the Expected Receiving Water Concentration under Critical Conditions

When using a steady-state model, the permit writer, or water quality modeler, determines the impact of the effluent discharge on the receiving water under critical conditions. This step examines how this steady-state analysis is conducted in situations where there is incomplete mixing and then provides a detailed discussion of this analysis for situations where there is rapid and complete mixing.

How are *critical conditions* defined?

When using a steady-state water quality model, permit writers generally input values that reflect critical conditions. State permitting procedures should guide permit writers in this task. When characterizing the effluent and receiving water for water quality-based permitting, the permit writer should follow the permitting authority's policies and procedures for selecting the critical conditions to use in a steady-state model. The discussion in section 6.2.4 above provides a discussion of how those values might be selected.

Permit writers generally would input into a steady-state model for a reasonable potential analysis the critical conditions identified in the effluent and receiving water characterization discussed in section 6.2.4 above. Recall that critical conditions include the following:

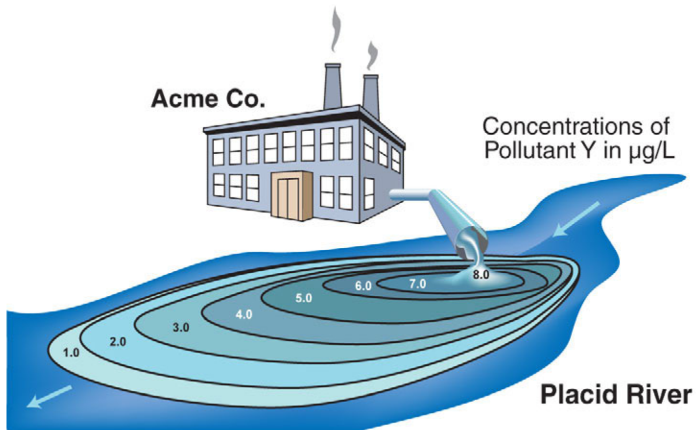
- Effluent critical conditions
  - Flow.
  - Pollutant concentration.
- Receiving water critical conditions
  - Flow (for rivers and streams).
  - Pollutant concentration.
  - Other receiving water characteristics such as tidal flux, temperature, pH, or hardness (depending on the waterbody and pollutant of concern)

As discussed in section 6.2.4.1 above, EPA and other permitting authorities have developed guidance for determining those critical conditions. Permit writers should rely on their permit authority's policies and procedures or past practices to determine values for all other critical conditions.

Expected Receiving Water Concentration in an Incomplete Mixing Situation

Exhibit 6-12 illustrates a situation where there is incomplete mixing of a discharge from a hypothetical facility, Acme Co., with the receiving water, the Placid River. The concentration of the pollutant of concern discharged by Acme Co. (Pollutant Y) is highest nearest the point of discharge and gradually decreases until the pollutant is completely mixed with the receiving water. To determine expected receiving water concentrations resulting from the Acme Co.'s discharge of Pollutant Y to the Placid River, the permit writer, or water quality modeler, would use the appropriate incomplete mixing model, calibrated to actual observations from field studies or dye studies, to simulate mixing under critical conditions. In Step 3 below, the concentrations of the pollutant of concern in the receiving water, as predicted by the water quality model, will be overlaid by a regulatory mixing zone established by the applicable water quality standard to determine whether WQBELs are needed.

Exhibit 6-12 Example of receiving water concentrations in an incomplete mixing situation determined using an incomplete mixing water quality model



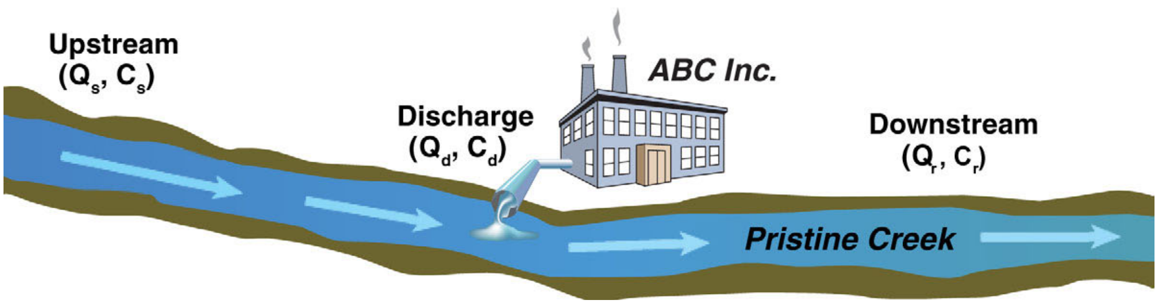
Expected Receiving Water Concentration in Rapid and Complete Mixing Situation

For many pollutants, if there is rapid and complete mixing in a river or stream, the permit writer could use the simple mass-balance equation presented in Exhibit 6-11 above to determine the expected receiving water concentration of the pollutant of concern under critical conditions. As noted previously, the simple mass-balance equation is a very basic steady-state model that can be used for most toxic pollutants, conservative pollutants, and other pollutants for which near-field effects are the primary concern. In Exhibit 6-13, that equation is applied to ABC Inc.'s, discharge of Pollutant Z (a conservative pollutant) to Pristine Creek under conditions of rapid and complete mixing. The mass-balance equation is rearranged to show how it would be used in a reasonable potential analysis.

To use the simple mass-balance equation to predict receiving water impacts for a reasonable potential analysis, the permit writer needs to input one value for each variable and solve the equation for C_r, the downstream concentration of the pollutant. Because this model, like other steady-state models, uses a single value for each variable, the permit writer should be sure that the values selected reflect critical conditions for the discharge and the receiving water. In Exhibit 6-14, those critical conditions have been identified and the equation has been solved for C_r.

It is important for permit writers to remember that, in some situations, the selected steady-state model could be more complex than the simple mass-balance equation shown. For example, there could be other pollutant sources along the stream segment; the pollutant might not be conservative (e.g., BOD); or the parameter to be modeled might be affected by multiple pollutants (e.g., dissolved oxygen affected by BOD and nutrients). For illustrative purposes, this example focuses on a situation where using a simple mass-balance equation is sufficient (i.e., rapid and complete mixing of a conservative pollutant in a river or stream under steady-state conditions).

Exhibit 6-13 Mass-balance equation for reasonable potential analysis for conservative pollutant under conditions of rapid and complete mixing



The mass-balance equation can be used to determine whether the discharge from ABC Inc., would cause, have the reasonable potential to cause, or contribute to an excursion above the water quality standards applicable to Pristine Creek. The equation is used to predict the concentration of Pollutant Z, a conservative pollutant, in Pristine Creek under critical conditions. The predicted concentration can be compared to the applicable water quality criteria for Pollutant Z. Assume the discharge mixes rapidly and completely with Pristine Creek.

Mass	=	**Flow** (Q) in million gallons per day (mgd) or cubic feet per second (cfs)	X	**Pollutant concentration** (C) in milligrams per liter (mg/L)

$$Q_sC_s + Q_dC_d = Q_rC_r$$

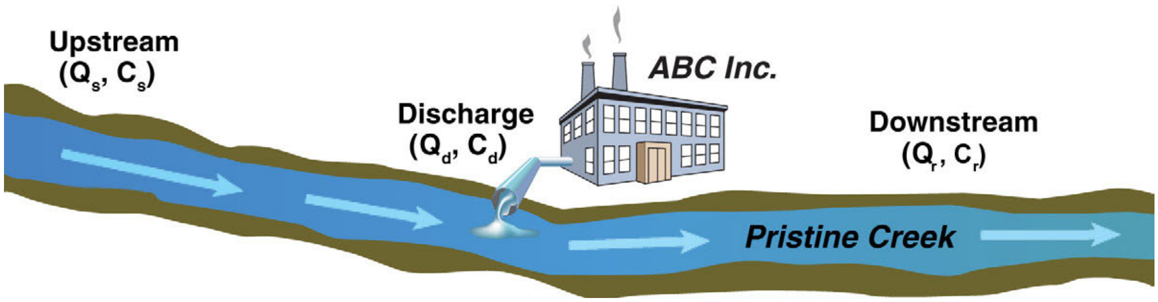
where

Q_s	=	critical stream flow in mgd or cfs above point of discharge
C_s	=	critical background in-stream pollutant concentration in mg/L
Q_d	=	critical effluent flow in mgd or cfs
C_d	=	critical effluent pollutant concentration in mg/L
Q_r	=	resultant in-stream flow, after discharge in mgd or cfs ($Q_r = Q_s + Q_d$)
C_r	=	resultant in-stream pollutant concentration in mg/L (after complete mixing occurs)

Rearrange the equation to determine the concentration of Pollutant Z in the waterbody downstream of a discharge under critical conditions:

$$C_r = \frac{(Q_d)(C_d) + (Q_s)(C_s)}{Q_r}$$

Exhibit 6-14 Example of applying mass-balance equation to conduct reasonable potential analysis for conservative pollutant under conditions of rapid and complete mixing



Mass-Balance Equation: $Q_sC_s + Q_dC_d = Q_rC_r$

Dividing both sides of the mass-balance equation by Q_r gives the following:

$$C_r = \frac{(Q_d)(C_d) + (Q_s)(C_s)}{Q_r}$$

where C_r is the receiving water concentration downstream of the discharge

The following values are known for ABC Inc. and Pristine Creek:

Q_s = critical upstream flow (water quality standards allow a dilution allowance of up to 100% of 1Q10 low flow for rapid and complete mixing)	= 1.20 cfs
C_s = critical upstream concentration of Pollutant Z in Pristine Creek	= 0.75 mg/L
Q_d = critical discharge flow	= 0.55 cfs
C_d = statistically projected critical discharge concentration of Pollutant Z	= 2.20 mg/L
Q_r = downstream flow	= Qd + Qs = 0.55 + 1.20 = 1.75 cfs

Acute aquatic life water quality criterion for Pollutant Z in Pristine Creek = 1.0 mg/L

Find the projected downstream concentration (C_r) by inserting the given values into the equation as follows:

$$C_r = \frac{(0.55\,\text{cfs})(2.20\,\text{mg/L}) + (1.20\,\text{cfs})(0.75\,\text{mg/L})}{(1.75\,\text{cfs})}$$

= 1.2 mg/L of Pollutant Z*

* calculated to 2 significant figures

6.3.2.3 Step 3: Answer the Question, Is There Reasonable Potential?

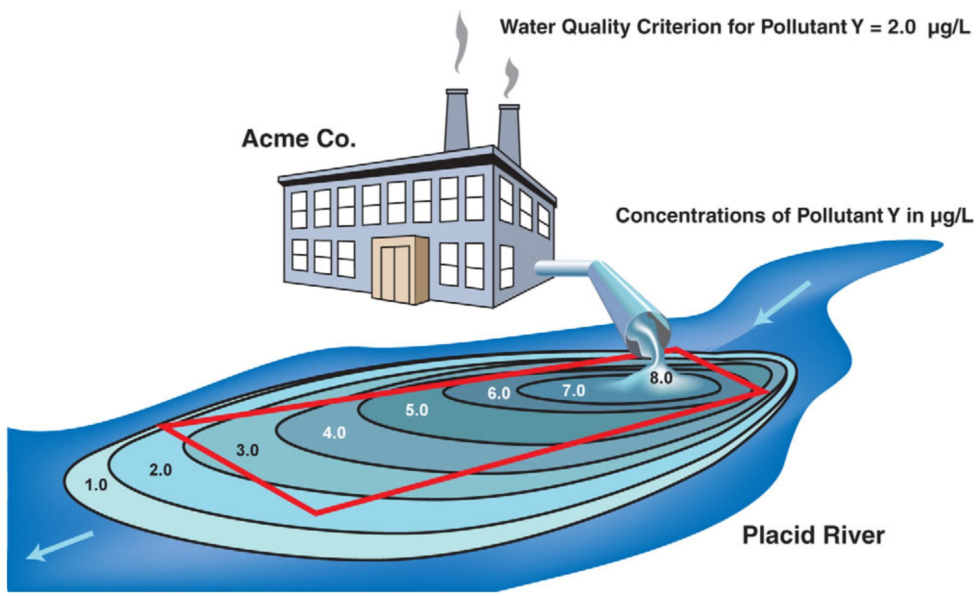
The next step in the reasonable potential analysis is to consider the results of water quality modeling to answer the question, *Is there reasonable potential?*

- For most pollutants, if the receiving water pollutant concentration projected by a steady-state model (e.g., a simple mass-balance equation or a more complex model) exceeds the applicable water quality criterion, there is *reasonable potential*, and the permit writer must calculate WQBELs. (Note that for dissolved oxygen, reasonable potential would occur if the water quality model indicates that the projected effluent concentration of the oxygen-demanding pollutants would result in depletion of dissolved oxygen below acceptable values in the receiving water).
- If the projected concentration is equal to or less than the applicable criterion, there is no reasonable potential and, thus far, there is no demonstrated need to calculate WQBELs.

Reasonable Potential Determination in an Incomplete Mixing Situation

To determine whether there is reasonable potential in an incomplete mixing situation, the permit writer would compare the projected concentration of the pollutant of concern at the edge of the regulatory mixing zone or after accounting for the available dilution allowance, with the applicable water quality criterion. Exhibit 6-15 illustrates the reasonable potential determination for Acme Co. in a situation where the regulatory mixing zone is described by a geometric shape. In the example, the water quality criterion for Pollutant Y being considered is 2.0 micrograms per liter (µg/L). The illustration shows that at many points along the edge of the regulatory mixing zone specified by the water quality standards, which is represented by the rectangle, the concentration of Pollutant Y exceeds 2.0 µg/L. Therefore, there is reasonable potential, and the permit writer must calculate WQBELs for Pollutant Y for Acme Co.

Exhibit 6-15 Reasonable potential determination in an incomplete mixing situation



Reasonable Potential Determination in a Rapid and Complete Mixing Situation

In the rapid and complete mixing example for ABC, Inc., shown in Exhibit 6-14 above, a projected downstream concentration (C_r) of 1.2 mg/L of Pollutant Z was calculated. The permit writer would compare the calculated concentration to the acute aquatic life water quality criterion of 1.0 mg/L for Pollutant Z in Pristine Creek presented in Exhibit 6-14. Because 1.2 mg/L > 1.0 mg/L, the projected downstream concentration exceeds the water quality criterion; therefore, there is a reasonable potential for the water quality criterion to be exceeded, and the permit writer must calculate WQBELs for Pollutant Z.

A permit writer should repeat the reasonable potential analysis for all applicable criteria for the pollutant of concern and must remember that the critical conditions could differ depending on the criterion being evaluated. For example, the critical stream flow used when considering the acute aquatic life criterion might be the 1Q10 low flow, whereas the critical stream flow used when considering the chronic aquatic life criterion might be the 7Q10 low flow. If calculations demonstrate that the discharge of a pollutant of concern would cause, have the reasonable potential to cause, or contribute to an excursion of *any one* of the applicable criteria for that pollutant, the permit writer must develop WQBELs for that pollutant.

In addition, it is important for permit writers to remember that they must repeat the reasonable potential analysis for each pollutant of concern and calculate WQBELs where there is reasonable potential. For each pollutant for which there is no reasonable potential, the permit writer should consider whether there are any existing WQBELs in the previous permit and whether they should be retained. The permit writer would complete an anti-backsliding analysis (see Chapter 7 of this manual) to determine whether it is possible to remove any existing WQBELs from the reissued permit.

6.3.2.4 Step 4: Document the Reasonable Potential Determination in the Fact Sheet

As a final step, permit writers need to document the details of the reasonable potential analysis in the NPDES permit fact sheet. The permit writer should clearly identify the information and procedures used to determine the need for WQBELs. The goal of that documentation is to provide the NPDES permit applicant and the public a transparent, reproducible, and defensible description of how each pollutant was evaluated, including the basis (i.e., reasonable potential analysis) for including or not including a WQBEL for any pollutant of concern.

6.3.3 Conducting a Reasonable Potential Analysis without Data

State implementation procedures might allow, or even require, a permit writer to determine reasonable potential through a qualitative assessment process without using available facility-specific effluent monitoring data or when such data are not available. For example, as noted in section 6.2.1.2 above, where there is a pollutant with a WLA from a TMDL, a permit writer must develop WQBELs or other permit requirements consistent with the assumptions of the TMDL. Even without a TMDL, a permitting authority could, at its own discretion, determine that WQBELs are needed for any pollutant associated with impairment of a waterbody. A permitting authority might also determine that WQBELs are required for specific pollutants for all facilities that exhibit certain operational or discharge characteristics (e.g., WQBELs for pathogens in all permits for POTWs discharging to contact recreational waters).

Types of information that the permit writer might find useful in a qualitative approach to determining reasonable potential include the following:

- Effluent variability information such as history of compliance problems and toxic impacts.
- Point and nonpoint source controls such as existing treatment technology, the type of industry, POTW treatment system, or BMPs in place.
- Species sensitivity data including in-stream data, adopted water quality criteria, or designated uses.
- Dilution information such as critical receiving water flows or mixing zones.

The permit writer should always provide justification for the decision to require WQBELs in the permit fact sheet or statement of basis and *must* do so where required by federal and state regulations. A thorough rationale is particularly important when the decision to include WQBELs is not based on an analysis of effluent data for the pollutant of concern.

After evaluating all available information characterizing the nature of the discharge without effluent monitoring data for the pollutant of concern, if the permit writer is not able to decide whether the discharge causes, has the reasonable potential to cause, or contributes to an excursion above a water quality criterion, he or she may determine that effluent monitoring should be required to gather additional data. The permit writer might work with the permittee to obtain data before permit issuance, if sufficient time exists, or could require the monitoring as a condition of the newly issued or reissued permit. The permit writer might also include a clause in the permit that would allow the permitting authority to reopen the permit and impose an effluent limitation if the required monitoring establishes that there is reasonable potential that the discharge will cause or contribute to an excursion above a water quality criterion.

6.4 Calculate Parameter-specific WQBELs

If a permit writer has determined that a pollutant or pollutant parameter is discharged at a level that will cause, have reasonable potential to cause, or contribute to an excursion above any state water quality standard, the permit writer must develop WQBELs for that pollutant parameter. This manual presents the approach recommended by EPA's TSD for calculating WQBELs for toxic (priority) pollutants. Many permitting authorities apply those or similar procedures to calculate WQBELs for toxic pollutants and for a number of conventional or nonconventional pollutants with effluent concentrations that tend to follow a lognormal distribution. Permit writers should consult permitting authority policies and procedures to determine the methodology specific to their authorized NPDES permitting program, including the approach for pollutants with effluent concentrations that do not follow a lognormal distribution.

6.4.1 Calculating Parameter-specific WQBELs from Aquatic Life Criteria

The TSD process for calculating WQBELs from aquatic life criteria follows five steps as shown in Exhibit 6-16 and discussed in detail below.

Exhibit 6-16 Calculating parameter-specific WQBELs from aquatic life criteria

Step 1.	Determine acute and chronic WLAs
Step 2.	Calculate long-term average (LTA) concentrations for each WLA
Step 3.	Select the lowest LTA as the performance basis for the permitted discharger
Step 4.	Calculate an average monthly limitation (AML) and a maximum daily limitation (MDL)
Step 5.	Document the calculation of WQBELs in the fact sheet.

6.4.1.1 Step 1: Determine Acute and Chronic WLAs

Before calculating a WQBEL, the permit writer will first need to determine the appropriate WLAs for the point source discharge based on both the acute and chronic criteria. A WLA may be determined from a TMDL or calculated for an individual point source directly. Where an EPA-approved TMDL has been developed for a particular pollutant, the WLA for a specific point source discharger is the portion of that TMDL that is allocated to that point source, as discussed in section 6.2.1.2 above. Where no TMDL is available, a water quality model generally is used to calculate a WLA for the specific point source discharger. The WLA is the loading or concentration of pollutant that the specific point source may discharge while still allowing the water quality criterion to be attained downstream of that discharge. Of course, the WLA calculation should take into account any reserve capacity, safety factor, and contributions from other point and nonpoint sources as might be required by the applicable water quality standards regulations or implementation policies.

When a WLA is not given as part of a TMDL or where a separate WLA is needed to address the near-field effects of a discharge on water quality criteria, permit writers will, in many situations, use a steady-state water quality model to determine the appropriate WLA for a discharge. As discussed in section 6.3 above, steady-state models generally are run under a single set of critical conditions for protection of receiving water quality. If a permit writer uses a steady-state model with a specific set of critical conditions to assess reasonable potential, he or she generally may use the same model and critical conditions to calculate a WLA for the same discharge and pollutant of concern.

As with the reasonable potential assessment, the type of steady-state model used to determine a WLA depends on the type of mixing that occurs in the receiving water and the type of pollutant or parameter being modeled. As discussed in section 6.3.2 above, permit writers can use the mass-balance equation as a simple steady-state model for many pollutants, such as most toxic (priority) pollutants or any pollutant that can be treated as a conservative pollutant when considering near-field effects, if there is rapid and complete mixing in the receiving water. For pollutants or discharge situations that do not have those characteristics (e.g., non-conservative pollutants, concern about effects on a downstream waterbody), a water quality model other than the mass-balance equation would likely be more appropriate.

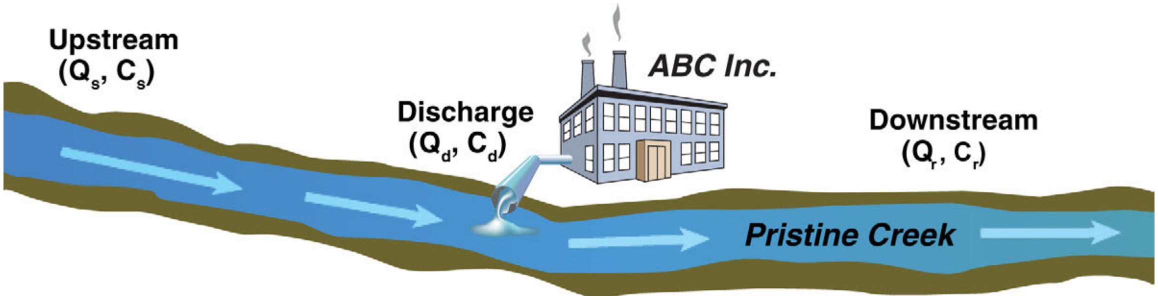
The mass-balance equation is presented again in Exhibit 6-17. In the exhibit, the equation is rearranged to show how it would be used to calculate a WLA for a conservative pollutant discharged to a river or stream under conditions of rapid and complete mixing.

6.4.1.2 Step 2: Calculate LTA Concentrations for Each WLA

The requirements of a WLA generally must be interpreted in some way to be expressed as an effluent limitation. The goal of the permit writer is to derive effluent limitations that are enforceable, adequately account for effluent variability, consider available receiving water dilution, protect against acute and chronic impacts, account for compliance monitoring sampling frequency, and assure attainment of the WLA and water quality standards. In developing WQBELs, the permit writer develops limitations that require a facility to perform in such a way that the concentration of the pollutant of concern in the effluent discharged is nearly always below the WLA.

To accomplish that goal, EPA has developed a statistical permit limitation derivation procedure to translate WLAs into effluent limitations *for pollutants with effluent concentration measurements that tend to follow a lognormal distribution*. EPA believes that this procedure, discussed in Chapter 5 of the TSD, results in defensible, enforceable, and protective WQBELs for such pollutants. In addition, a number of states have adopted procedures based on, but not identical to, EPA's guidance that also provide defensible, enforceable, and protective WQBELs. Permit writers should always use the procedures adopted by their permitting authority. In addition, permit writers should recognize that alternative procedures would be used to calculate effluent limitations for pollutants with effluent concentrations that cannot generally be described using a lognormal distribution.

Exhibit 6-17 Example of applying mass-balance equation to calculate WLAs for conservative pollutant under conditions of rapid and complete mixing



$$Q_sC_s + Q_dC_d = Q_rC_r$$

where

Q_s	=	background stream flow in mgd or cfs above point of discharge
C_s	=	background in-stream pollutant concentration in mg/L
Q_d	=	effluent flow in mgd or cfs
C_d	=	effluent pollutant concentration in mg/L **= WLA**
Q_r	=	resultant in-stream flow, after discharge in mgd or cfs
C_r	=	resultant in-stream pollutant concentration in mg/L (after complete mixing occurs)

Rearrange the equation to determine the WLA (C_d) for ABC Inc., necessary to achieve the acute water quality criterion for Pollutant Z in Pristine Creek (C_r) downstream of the discharge:

$$C_d = \frac{Q_rC_r - Q_sC_s}{Q_d}$$

The following values are known for ABC Inc., and Pristine Creek:

Q_s = critical upstream flow (water quality standards allow a dilution allowance of up to 100% of 1Q10 low flow for rapid and complete mixing)	= 1.20 cfs
C_s = upstream concentration of Pollutant Z in Pristine Creek	= 0.75 mg/L
Q_d =discharge flow	= 0.55 cfs
Q_r = downstream flow	= Qd + Qs = 0.55 + 1.20 = 1.75 cfs
C_r = acute water quality criterion for Pollutant Z in Pristine Creek	= 1.0 mg/L

Determine the WLA for ABC Inc., by inserting the given values into the equation as follows:

$$\text{WLA for ABC Inc.} = C_d = \frac{(1.75\ \text{cfs})(1.0\ \text{mg/L}) - (1.20\ \text{cfs})(0.75\ \text{mg/L})}{(0.55\ \text{cfs})}$$

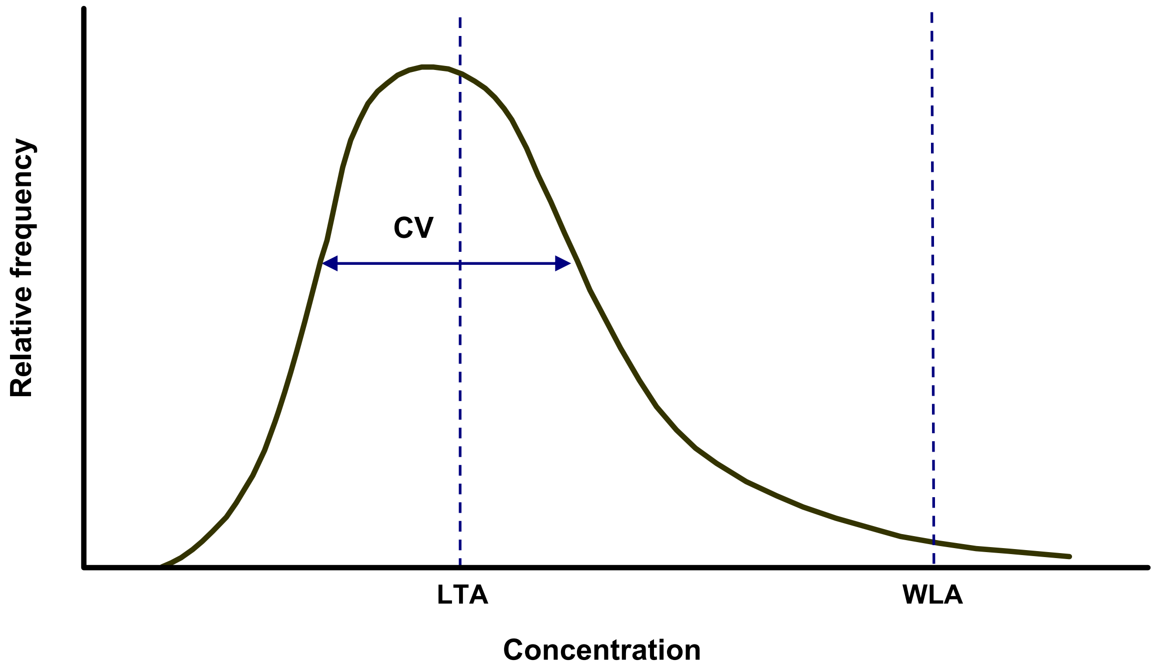
$$= 1.5\ \text{mg/L of Pollutant Z}\ ^*$$

* calculated to 2 significant figures

For those pollutants with effluent concentrations that do follow a lognormal distribution, the distribution can be described by determining a long-term average (or LTA) that ensures that the effluent pollutant concentration remains nearly always below the WLA and by the CV, a measure of the variability of data around the LTA. Exhibit 6-18 illustrates a lognormal distribution with the LTA, CV, and WLA highlighted.

When applying aquatic life criteria, a permit writer generally establishes a WLA based on the acute aquatic life criterion and a WLA based on the chronic aquatic life criterion. Thus, the permit writer determines two LTAs—one that would ensure that an effluent concentration is nearly always below the acute WLA and one that would ensure that an effluent concentration nearly always below the chronic WLA. Each LTA, acute and chronic, would represent a different performance expectation for the discharger.

Exhibit 6-18 Example of lognormal distribution of effluent pollutant concentrations and calculation of LTA



6.4.1.3 Step 3: Select the Lowest LTA as the Performance Basis for the Permitted Discharger

EPA recommends that WQBELs be based on a single performance expectation for a facility; therefore, once a permit writer has calculated LTA values for each WLA, he or she would select only one of those LTAs to define the required performance of the facility and serve as the basis for WQBELs. Because WQBELs must assure attainment of all applicable water quality criteria, the permit writer would select the lowest LTA as the basis for calculating effluent limitations. Selecting the lowest LTA would ensure that the facility's effluent pollutant concentration remains below all the calculated WLAs nearly all the time. Further, because WLAs are calculated using critical receiving water conditions, the limiting LTA would also ensure that water quality criteria are fully protected under nearly all conditions.

6.4.1.4 Step 4: Calculate an Average Monthly Limitation (AML) and a Maximum Daily Limitation (MDL)

The NPDES regulations at § 122.45(d) require that all effluent limitations be expressed, unless impracticable, as both AMLs and MDLs for all discharges other than POTWs and as both AMLs and average weekly limitations (AWLs) for POTWs. The AML is the highest allowable value for the average of daily discharges over a calendar month. The MDL is the highest allowable daily discharge measured during a calendar day or 24-hour period representing a calendar day. The AWL is the highest allowable value for the average of daily discharges over a calendar week. For pollutants with limitations expressed in units of mass, the daily discharge is the total mass discharged over the day. For limitations expressed in other units, the daily discharge is the average measurement of the pollutant over the period of a day.

In the TSD, EPA recommends establishing an MDL, rather than an AWL, for discharges of toxic pollutants from POTWs. That approach is appropriate for at least two reasons. First, the basis for the AWL for POTWs is the secondary treatment requirements discussed in section 5.1.1.1 of this manual and is not related to the need for assuring attainment of water quality standards. Second, an AWL, which could be the average of up to seven daily discharges, could average out peak toxic concentrations and, therefore, the discharge's potential for causing acute toxic effects might be missed. An MDL would be more likely to identify potential acutely toxic impacts.

Chapter 5 of the TSD includes statistical tools for calculating MDLs and AMLs from the LTA value selected in Step 3 above. Again, note that those procedures apply to *pollutants with effluent concentration measurements that tend to follow a lognormal distribution*. EPA has not developed guidance on procedures for calculating effluent limitations for pollutants with effluent concentrations that generally cannot be described using a lognormal distribution. For such pollutants, permit writers should use other procedures as recommended by their permitting authority in its policies, procedures, or guidance.

Whether using the TSD procedures or other procedures for calculating WQBELs, the objective is to establish limitations calculated to require treatment plant performance levels that, after considering acceptable effluent variability, would have a very low statistical probability of exceeding the WLA and, therefore, would comply with the applicable water quality standards under most foreseeable conditions.

6.4.1.5 Step 5: Document Calculation of WQBELs in the Fact Sheet

Permit writers should document in the NPDES permit fact sheet the process used to develop WQBELs. The permit writer should clearly identify the data and information used to determine the applicable water quality standards and how that information, or any applicable TMDL, was used to derive WQBELs and explain how the state's antidegradation policy was applied as part of the process. The information in the fact sheet should provide the NPDES permit applicant and the public a transparent, reproducible, and defensible description of how the permit writer properly derived WQBELs for the NPDES permit.

6.4.2 Calculating Chemical-specific WQBELs based on Human Health Criteria for Toxic Pollutants

Developing WQBELs for toxic pollutants affecting human health is somewhat different from calculating WQBELs for other pollutants because (1) the exposure period of concern is generally longer (e.g., often a lifetime exposure) and (2) usually the average exposure, rather than the maximum exposure, is of concern. EPA's recommended approach for setting WQBELs for toxic pollutants for human health protection is to set the AML equal to the WLA calculated from the human health toxic pollutant criterion and calculate the MDL from the AML. Section 5.4.4 of the TSD describes statistical procedures used for such calculations for pollutants with effluent concentrations that follow a lognormal distribution. Once again, for pollutants with effluent concentrations that do not follow a lognormal distribution, permit writers should use other procedures as specified by their permitting authority.

If the permit writer calculates chemical-specific WQBELs from human health criteria, he or she should compare the limitations to any other calculated WQBELs (e.g., WQBELs based on aquatic life criteria) and TBELs and apply antidegradation and anti-backsliding requirements to determine the final limitations that meet all technology and water quality standards. As discussed above, that process should be documented in the fact sheet for the NPDES permit.

6.5 Calculate Reasonable Potential and WQBELs for WET

WET tests measure the degree of response of exposed aquatic test organisms to an effluent mixed in some proportion with control water (e.g., laboratory water or a non-toxic receiving water sample). WET testing is used as a second approach, in addition to the chemical-specific approach, to implementing water quality standards in NPDES permits. This section provides a brief introduction to WET testing and WET limitations.

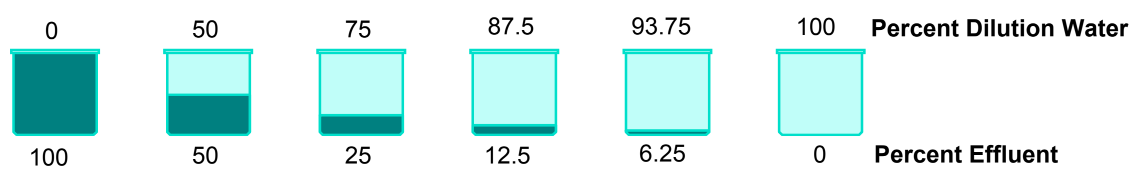
Test of Significant Toxicity (TST)

At the time of the writing of this guidance manual, EPA had recently published a new statistical approach that assesses the whole effluent toxicity (WET) measurement of wastewater effects on specific test organisms' ability to survive, grow, and reproduce. This new approach is called the Test of Significant Toxicity (TST) and is a statistical method that uses hypothesis testing techniques based on research and peer-reviewed publications. The hypothesis test under the TST approach examines whether an effluent, at the critical concentration (e.g., in-stream waste concentration [IWC]), and the control within a WET test differ by an unacceptable amount (the amount that would have a measured detrimental effect on the ability of aquatic organisms to thrive and survive). The TST implementation document and the TST technical document are available at the NPDES WET Website <www.epa.gov/npdes/wet>.

6.5.1 Types of WET Tests

In many WET tests, the effluent and control water are mixed in varying proportions to create a dilution series. Exhibit 6-19 is an example of a typical dilution series used in WET testing.

Exhibit 6-19 Example of typical dilution series



There are two types of WET tests: acute and chronic. An acute toxicity test usually is conducted over a short time, generally 96 hours or less, and the endpoint measured is mortality. The endpoint for an acute test is often expressed as an LC_{50} (i.e., the percent of effluent that is lethal to 50 percent of the exposed test organisms). A chronic toxicity test is usually conducted during a critical life phase of the organism and the endpoints measured are mortality and sub-lethal effects, such as changes in reproduction and growth. A chronic test can occur over a matter of hours or days, depending on the species tested and test endpoint. The endpoint of a chronic toxicity test often is expressed in one of the following ways:

- No observed effect concentration (NOEC), the highest concentration of effluent (i.e., highest percent effluent) at which no adverse effects are observed on the aquatic test organisms.
- Lowest observed effect concentration (LOEC), the lowest concentration of effluent that causes observable adverse effects in exposed test organisms.

- Inhibition concentration (IC), a point estimate of the effluent concentration that would cause a given percent reduction in a biological measurement of the test organisms.
- Effect concentration (EC), a point estimate of the effluent concentration that would cause an observable adverse effect in a given percentage of test organisms.

For additional information on WET monitoring and WET test methods, see section 8.2.4 of this manual.

6.5.2 Expressing WET Limitations or Test Results

There are two options for expressing WET limitations or test results. First, WET limitations or test results can be expressed directly in terms of the WET test endpoints discussed above (e.g., LC_{50}, NOEC, and IC_{25}). Alternatively, the limitations or test results can be expressed in terms of *toxic units* (TUs). A TU is the inverse of the sample fraction, calculated as 100 divided by the percent effluent. Exhibit 6-20 presents example TUs for expressing acute and chronic test results.

Exhibit 6-20 Example of toxic units

If an **acute test** result is a LC_{50} of 60 percent, that result can be expressed as

$$\frac{100}{60} = 1.7 \text{ acute toxic units} = 1.7\ TU_a$$

If a **chronic test** result is an IC_{25} of 40 percent effluent, that result can be expressed as

$$\frac{100}{40} = 2.5 \text{ chronic toxic units} = 2.5\ TU_c$$

It is important to distinguish acute TUs (TU_a) from chronic TUs (TU_c). The difference between TU_a and TU_c can be likened to the difference between miles and kilometers. Both miles and kilometers are used to measure distance, but a distance of 1.0 mile is not the same as a distance of 1.0 kilometer. Likewise, both TU_a and TU_c are expressions of the toxicity of an effluent, but 1.0 TU_a is not the same as 1.0 TU_c. It is possible, however, to determine the relationship between the acute toxicity of an effluent and the chronic toxicity of that same effluent, just as it is possible to determine the relationship between miles and kilometers (i.e., through a conversion factor). Unlike the conversion between miles and kilometers that remains constant, the conversion factor between acute and chronic toxic units varies from effluent to effluent.

For an effluent, the permit writer could develop a conversion factor that would allow conversion of TU_a into equivalent TU_c or vice versa. This conversion factor is known as an acute-to-chronic ratio (ACR) for that effluent. The ACR for an effluent may be calculated where there are at least 10 sets of paired acute and chronic WET test data available. The ACR is determined by calculating the mean of the individual ACRs for each pair of acute and chronic WET tests. Where there are not sufficient data to calculate an ACR for an effluent (i.e., less than 10 paired sets of acute and chronic WET test data), EPA recommends a default value of ACR = 10. Exhibit 6-21 presents examples showing how the ACR converts TU_a into TU_c, how to calculate an ACR from existing data, and how, once an ACR is calculated, a permit writer could estimate the chronic toxicity of an effluent sample from its measured acute toxicity or vice versa.

Exhibit 6-21 Using the ACR

The ACR is expressed

$$ACR = \frac{\text{Acute Endpoint}}{\text{Chronic Endpoint}} = \frac{LC_{50}}{IC_{25}}$$

A TU is the inverse of the sample fraction. Therefore, by definition

$$TU_a = \frac{100}{LC_{50}} \qquad TU_c == \frac{100}{IC_{25}}$$

Consequently, toxicity as percent sample, may be expressed

$$LC_{50} = \frac{100}{TU_a} \qquad IC_{25} = \frac{100}{TU_c}$$

Substituting into the original equation gives

$$ACR = \frac{LC_{50}}{IC_{25}} = \frac{\frac{100}{TU_a}}{\frac{100}{TU_c}} = \frac{TU_c}{TU_a}$$

Example 1

Given: LC_{50} = 28%, NOEC = 10%

$$ACR = \frac{LC_{50}{}^{0}}{IC_{25}} = \frac{28\%}{10\%} = 2.8$$

Example 2

Given: TU_a = 3.6, TU_c = 10.0

$$ACR = \frac{TU_c}{TU_a} = \frac{10.0}{3.6} = 2.8$$

Example 3

Given: Toxicity data for a facility's effluent for *C. dubia*. as presented in the table to the right.

The ACR in the third column is calculated using the following equation:

$$ACR = \frac{LC_{50}}{IC_{25}}$$

LC_{50} (% effluent)	IC_{25} (% effluent)	ACR
62	10	6.2
18	10	1.8
68	25	2.7
61	10	6.1
63	25	2.5
70	25	2.8
17	5	3.4
35	10	3.5
35	10	3.5
35	25	1.4
47	10	4.7
Mean		**3.5**

Example 4

Given: TU_a = 1.8, ACR = 3.5

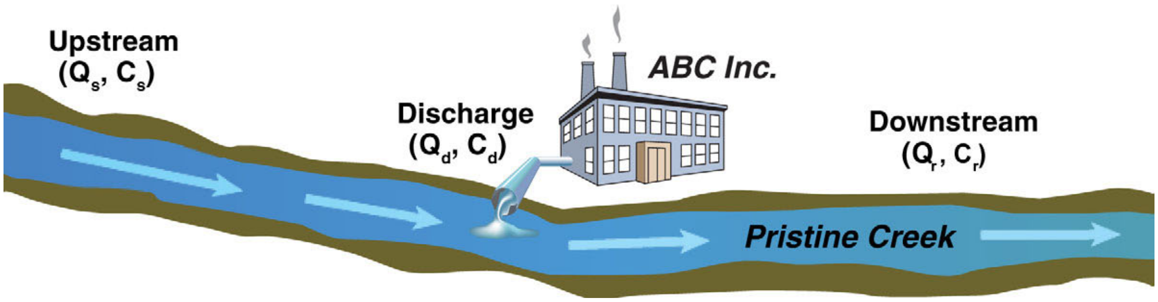
$$ACR = \frac{TU_c}{TU_a} \qquad TU_c = ACR \times TU_a$$

$$\text{Estimated } TUc = ACR \times TU_a = 3.5\,\frac{TU_c}{TU_a} \times 1.8\ TU_a = 6.3\ TU_c$$

6.5.3 Determining the Need for WET Limitations

If a state has numeric criteria for WET, a permit writer could use the results of WET tests to project acute or chronic toxicity in the receiving water after accounting for the applicable dilution allowance or mixing zone made available in the water quality standards. The permit writer would compare the projected toxicity of the receiving water to the applicable water quality criterion for WET. If the projected toxicity exceeds the applicable numeric water quality criterion for WET, the discharge would cause, have the reasonable potential to cause, or contribute to an excursion above the applicable water quality standards, and the permit writer must develop a WQBEL for WET [see § 122.44(d)(1)(iv)]. In that way, numeric criteria for WET can be treated similarly to chemical-specific criteria. Exhibit 6-22 provides an example of how the mass-balance equation is used to conduct a reasonable potential analysis for WET.

Exhibit 6-22 Example of mass-balance equation for a WET reasonable potential analysis



The mass-balance equation can be used to determine whether the discharge from ABC Inc. would cause, have the reasonable potential to cause, or contribute to toxicity in Pristine Creek that exceeds the numeric water quality criteria for acute or chronic toxicity. Assume the discharge mixes rapidly and completely with Pristine Creek.

Mass-Balance Equation: $Q_sC_s + Q_dC_d = Q_rC_r$

Dividing both sides of the mass-balance equation by Q_r gives the following:

$$C_r = \frac{(Q_d)(C_d) + (Q_s)(C_s)}{Q_r}$$

The following values are known for ABC Inc. and Pristine Creek:

Q_s = Critical upstream flow	(1Q10 for acute protection)	= 23.6 cfs
	(7Q10 for chronic protection)	= 70.9 cfs
C_s = Upstream toxicity in Pristine Creek	(acute)	= 0 TU_a
	(chronic)	= 0 TU_c
Q_d = Discharge flow		= 7.06 cfs
C_d = Discharge toxicity	(acute)	= 2.50 TU_a
	(chronic)	= 8.00 TU_c
Q_r = Downstream flow		= $Q_d + Q_s$
Acute Water Quality Criterion in Pristine Creek		= 0.3 TU_a
Chronic Water Quality Criterion in Pristine Creek		= 1.0 TU_c

Find the downstream concentration (C_r) by inserting the given values into the equation as follows:

For acute toxicity:

$$C_r = \frac{(7.06\ \text{cfs})(2.5\ TU_a) + (23.6\ \text{cfs})(0\ TU_a)}{7.06\ \text{cfs} + 23.6\ \text{cfs}} = 0.58\ TU_a$$

The downstream concentration (C_r) exceeds the water quality criterion for acute toxicity of 0.3 TU_a.

For chronic toxicity:

$$C_r = \frac{(7.06\ \text{cfs})(8.00\ TU_c) + (70.9\ \text{cfs})(0\ TU_c)}{7.06\ \text{cfs} + 70.9\ \text{cfs}} = 0.72\ TU_c$$

The downstream concentration (C_r) does not exceed the water quality criterion for chronic toxicity of 1.0 TU_c.

In Exhibit 6-22 above, the downstream concentration under critical conditions for the acute water quality criterion (C_r = 0.58 TU_a) exceeds the water quality criterion for acute toxicity (0.3 TU_a); therefore there is reasonable potential and WET limitations are required. WET limitations would be calculated in much the same way as limitations on specific chemicals. The limitations would be calculated to ensure that WET criteria are not exceeded after any available dilution or at the edge of the applicable mixing zone.

Where state water quality standards do not include numeric criteria for WET, a permit writer could evaluate the need for WQBELs for WET on the basis of narrative criteria; specifically, a narrative criterion stating that waterbodies must be free from *toxics in toxic amounts*. To make it easier for a permit writer to readily establish WET limitations in this situation, the permitting authority should have a policy for implementing the narrative criterion. Following the permitting authority's policy, if the permit writer determines that a discharge causes, has the reasonable potential to cause, or contributes to an in-stream excursion above a narrative criterion, the regulations at § 122.44(d)(1)(v) require that the permit include WQBELs for WET unless the permit writer demonstrates that parameter-specific limitations for the effluent are sufficient to attain and maintain applicable numeric and narrative water quality criteria. In other words, the permit must include WET limitations unless the permit writer is able to determine the specific pollutants that are the source of toxicity and include parameter-specific limitations for those pollutants that assure, and will continue to assure, attainment of water quality standards. If there are no criteria in the state water quality standards for the specific parameters causing the toxicity, the permit writer can establish WQBELs using one of three approaches outlined in § 122.44(d)(1)(vi):

- Use EPA's national recommended criteria.
- Calculate a numeric criterion that will attain and maintain the applicable narrative criterion.
- Control the pollutant using an indicator parameter for the pollutant of concern.

A permit also could include a requirement to conduct a toxicity identification evaluation and toxicity reduction evaluation (TIE/TRE) as a special condition in an NPDES permit. (Chapter 9 of this manual presents more information on special conditions.) A TIE/TRE is a site-specific study designed to systematically investigate and identify the causes of effluent toxicity problems, isolate the sources of that toxicity, identify and implement appropriate toxicity control options, and confirm the effectiveness of those control options and the reduction in toxicity. The permit writer might require a TIE/TRE when WET limitations are exceeded or, if there are no WET limitations in the permit, where WET testing demonstrates an unacceptable level of effluent toxicity. Because WET testing indicates the degree of toxicity of an effluent, but does not specifically identify the cause of that toxicity or ways to reduce toxicity, a TIE/TRE is necessary to achieve compliance with effluent limitations or other effluent toxicity requirements in NPDES permits. If a TIE/TRE is not required through the special conditions section of the permit, it could be required via a CWA section 308 letter, a CWA section 309 administrative order, or a consent decree.

6.6 Antidegradation Review

Early in the permit development process, a permit writer should check the state's antidegradation policy and implementation methods to determine what tier(s) of protection, if any, the state has assigned to the proposed receiving water for the parameter(s) of concern. The regulations concerning antidegradation and each of the tiers are described above in section 6.1.1.3. The tier of antidegradation protection is important for determining the required process for developing the water quality-based permit limits and conditions. In some cases, where a waterbody is classified as Tier 3 for antidegradation purposes, the permit writer might find that it is not possible to issue a permit for the proposed activity.

If the state has not specified the tier, the permit writer will need to evaluate, in accordance with the state's implementation procedures, whether the receiving waterbody is of high water quality for the parameters of concern, and thus will require Tier 2 protection. After identifying the tier(s) of protection for the proposed receiving waterbody and parameter(s) of concern, the permit writer should consult the state's antidegradation implementation procedures relevant to the tier(s).

The following sections provide methods permit writers should consider for implementing, through the WQBEL development process, the three levels of protection typically found in a state's antidegradation policy. Implementation of the state's antidegradation policy could have a significant effect on the calculation of WQBELs.

6.6.1 Tier 1 Implementation

All waterbodies receive at least Tier 1 protection. Tier 1 protection means that the permit writer must include limits in the permit sufficient to maintain and protect water quality necessary to protect existing uses. In practice, for a Tier 1 receiving waterbody, the permit writer typically calculates the WQBELs on the basis of the applicable criteria because the state's designated uses and criteria to protect those uses must be sufficient to protect the existing uses. If a Tier 1 waterbody is impaired for a parameter that would be present in the proposed discharge, the permit writer should identify and consult any relevant TMDLs to determine what quantity of pollutant (if any) is appropriate.

6.6.2 Tier 2 Implementation

For new or increased discharges that could potentially lower water quality in high-quality waters, Tier 2 protection provides the state with a framework for making decisions regarding the degree to which it will protect and maintain the high water quality. A new or expanded discharge permit application typically triggers a Tier 2 antidegradation review. Depending on the outcome of the review, the permit could be written to maintain the existing high water quality or could be written to allow some degradation.

Each state's antidegradation policy or implementation procedures should describe the Tier 2 antidegradation review process. Though the process varies among states, EPA's antidegradation regulation at § 131.12 outlines the common elements of the process. To permit a new or increased discharge that would lower water quality, the state is required to make a finding on the basis of the following:

- The state must find that allowing lower water quality is necessary for important social or economic development in the area in which the waters are located.
  - The state would perform an alternatives analysis to evaluate whether the proposed discharge is actually *necessary* (i.e., whether there are less degrading feasible alternatives) and that might include consideration of a wide range of alternatives (e.g. non-discharging options, relocation of discharge, alternative processes, and innovative treatments).
  - The state should provide a justification of important social or economic development (or both) that would occur as a result of permitting the proposed discharge.
- The state's finding must be made after full satisfaction of its own intergovernmental coordination and public participation provisions.
- The state must assure that the highest statutory and regulatory requirements for all new and existing point sources will be achieved.
- The state must assure that all cost-effective and reasonable BMPs for nonpoint source control will be achieved.

- The state must assure that water quality will still protect existing uses.

If, after fulfilling the above conditions of the Tier 2 antidegradation review process, the state makes a determination to allow a new or increased discharge that would lower water quality, the permit writer may include such limitations in the NPDES permit for that discharge provided the limitations meet all other applicable technology and water quality standards.

6.6.3 Tier 3 Implementation

States identify their own ONRWs for Tier 3 protection, which requires that the water quality be maintained and protected. This is the most stringent level of protection. ONRWs often include waters in national or state parks, wildlife refuges, and waters of exceptional recreational or ecological significance. Waterbodies can be given Tier 3 protection regardless of their existing level of water quality. Some states implement Tier 3 by prohibiting any new or increased discharges to ONRWs or their tributaries that would result in lower water quality, with the exception of some limited activities such as those that would result in temporary changes in water quality ultimately resulting in restoration. Some states allow increased discharges as long as they are offset by equivalent or greater reductions elsewhere in the waterbody.

In addition to Tiers 1, 2, and 3, some states have a class of waters considered outstanding to the state and for which the state might have specific antidegradation requirements. Such waterbodies are sometimes referred to as *Tier 2 ½* waters because implementation of the antidegradation policy for them affords a greater degree of protection than Tier 2 but more flexibility than Tier 3.

Chapter 4 of EPA's WQS Handbook and the *Water Quality Standards Regulation Advance Notice of Proposed Rulemaking* (64 FR 36742, July 7, 1998) include additional information on implementing antidegradation policies. The permit writer should clearly explain the antidegradation analysis and how it affects calculation of WQBELs in the fact sheet or statement of basis for the permit.

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[1] U.S. Environmental Protection Agency. 1994. *Water Quality Standards Handbook: Second Edition* (WQS Handbook). EPA 823-B-94-005a. U.S. Environmental Protection Agency, Office of Water, Washington DC. <www.epa.gov/waterscience/standards/handbook/>.

[2] U.S. Environmental Protection Agency. 2001. *Streamlined Water-Effect Ratio Procedure for Discharges of Copper*. EPA-822-R-01-005. U.S. Environmental Protection Agency, Office of Science and Technology, Washington, DC. <www.epa.gov/waterscience/criteria/copper/copper.pdf>.

[3] Davies, Tudor T. 1997. *Establishing Site Specific Aquatic Life Criteria Equal to Natural Background.* U.S. Environmental Protection Agency, Office of Science and Technology, Washington, DC. <www.epa.gov/waterscience/library/wqcriteria/naturalback.pdf>.

[4] U.S. Environmental Protection Agency. 1991. *Technical Support Document for Water Quality-Based Toxics Control* (TSD). EPA-505/2-90-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC. <www.epa.gov/npdes/pubs/owm0264.pdf>.

[5] U.S. Environmental Protection Agency. 1990. *Biological Criteria: National Program Guidance for Surface Waters*. EPA-440/5-91-004. U.S. Environmental Protection Agency, Office of Science and Technology, Washington, DC. <www.epa.gov/bioindicators/html/biolcont.html>.

CHAPTER 9. Special Conditions

Special conditions in National Pollutant Discharge Elimination System (NPDES) permits supplement numeric effluent limitations and require the permittee to undertake activities designed to reduce the overall quantity of pollutants being discharged to waters of the United States, to reduce the potential for discharges of pollutants, or to collect information that could be used in determining future permit requirements.

There are many different reasons to incorporate special conditions into a permit including

- To address unique situations, such as facilities discharging pollutants for which data are absent or limited, making development of technology- or water quality-based effluent limitations (TBELs or WQBELs) more difficult or impossible.
- To incorporate preventive requirements, such as requirements to install process control alarms, containment structures, good housekeeping practices, and the like.
- To address foreseeable changes to discharges, such as planned changes to process, products, or raw materials that could affect discharge characteristics.
- To incorporate compliance schedules to provide the time necessary to comply with permit conditions.
- To incorporate other NPDES programmatic requirements (e.g., pretreatment, sewage sludge).
- To impose additional monitoring requirements that provide the permit writer with data to evaluate the need for changes in permit limitations.
- To increase or decrease monitoring requirements, depending on monitoring results or changes in processes or products.
- To impose requirements for special studies such as ambient stream surveys, toxicity identification evaluations (TIEs) and toxicity reduction evaluations (TREs), bioaccumulation studies, sediment studies, mixing or mixing zone studies, pollutant reduction evaluations, or other such information-gathering studies.

Section 9.1 below addresses several types of special conditions that apply to both municipal and non-municipal facilities. Section 9.2 addresses special conditions unique to municipal facilities and section 9.3 addresses special conditions for stormwater discharges associated with industrial activity.

9.1 Special Conditions Potentially Applicable to Any Type of Discharger

This section discusses several types of special conditions that could be included in any NPDES permit (i.e., municipal or non-municipal). Those special conditions can be thought of as the *ABCs* of special conditions and include the following:

- **A**dditional monitoring and special studies.
- **B**est management practices (BMPs).
- **C**ompliance schedules.

A summary of the use of those special conditions follows.

9.1.1 Additional Monitoring and Special Studies

Additional monitoring requirements, beyond those required under the effluent limitations section of the permit, and special studies are useful for collecting data that were not available to the permit writer for consideration during permit development. Additional monitoring requirements and special studies generally are used to supplement numeric effluent limitations or support future permit development activities. Examples of the types of special studies that could be required in an NPDES permit include the following:

- **Treatability studies:** Might be required in a permit when insufficient treatability information for a pollutant or pollutants would hinder a permit writer from developing defensible TBELs. Treatability studies can also be required when the permit writer suspects that a facility might not be able to comply with an effluent limitation.
- **Toxicity identification evaluation/toxicity reduction evaluation (TIE/TRE):** Could be required in a permit when wastewater discharges are found to be toxic using whole effluent toxicity (WET) tests. The purpose of those evaluations is to identify and control the sources of toxicity in an effluent. Further guidance related to U.S. Environmental Protection Agency (EPA) recommended TIE/TRE procedures and requirements is found in the following guidance manuals:
  - *Toxicity Reduction Evaluation Guidance for Municipal Wastewater Treatment Plants*[1] <www.epa.gov/npdes/pubs/tre.pdf>.
  - *Clarifications Regarding Toxicity Reduction and Identification Evaluations in the National Pollutant Discharge Elimination System Program*[2] <www.epa.gov/npdes/pubs/owmfinaltretie.pdf>.
  - *Generalized Methodology for Conducting Industrial Toxicity Reduction Evaluations*[3] (No link—see the endnote for ordering instructions).
  - *Methods for Aquatic Toxicity Identification Evaluations: Phase I Toxicity Characterization Procedures*. 2nd ed[4] <www.epa.gov/npdes/pubs/owm0330.pdf>.
  - *Toxicity Identification Evaluation: Characterization of Chronically Toxic Effluents, Phase I*[5] <www.epa.gov/npdes/pubs/owm0255.pdf>.
  - *Methods for Aquatic Toxicity Identification Evaluations: Phase II Toxicity Identification Procedures for Samples Exhibiting Acute and Chronic Toxicity*[6] <www.epa.gov/npdes/pubs/owm0343.pdf>.
  - *Methods for Aquatic Toxicity Identification Evaluations: Phase III Confirmation Procedures for Samples Exhibiting Acute and Chronic Toxicity*[7] <www.epa.gov/npdes/pubs/owm0341.pdf>.
- **Mixing or mixing zone studies:** Might be required in a permit to assist in determining how effluent and receiving water mix and in establishing a regulatory mixing zone that can be applied when developing WQBELs.
- **Sediment monitoring:** Could be included in a permit if a permit writer suspects that pollutants contained in wastewater discharges accumulate in the sediments of the receiving water.
- **Bioaccumulation studies:** Might be required in a permit to determine whether pollutants contained in wastewater discharges bioaccumulate in aquatic organisms (e.g., fish, invertebrates). Such studies could be required when water quality criteria are expressed in terms of fish tissue levels. Additional guidance related to evaluating the bioaccumulation potential of a pollutant can

be found in the *EPA Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors*[8] (No link—see the endnote for ordering instructions).

When establishing additional monitoring or special studies, permit writers must ensure that any requirements related to the study (e.g., special sampling or analytical procedures) are specified in the appropriate permit condition. In addition, permit writers should establish a reasonable schedule for completion and submission of the study or monitoring program. If the anticipated timeline is longer than one year, an interim progress report during the study is advisable.

9.1.2 Best Management Practices (BMPs)

In general, BMPs are actions or procedures to prevent or reduce the discharge of pollution to waters of the United States. Title 40 of the *Code of Federal Regulations* (CFR) section 122.2 includes the following in the definition of BMPs:

- Schedules of activities.
- Prohibitions of practices.
- Maintenance procedures.
- Treatment requirements.
- Operating procedures and practices to control
  - Plant site runoff.
  - Spillage or leaks.
  - Sludge or waste disposal.
  - Drainage from raw material storage areas.

9.1.2.1 When to Use BMPs

Clean Water Act (CWA) section 304(e) authorizes EPA to require BMPs as part of effluent limitations guidelines and standards (effluent guidelines) to control plant site runoff, spillage or leaks, sludge or waste disposal, and drainage from raw material storage that it determines are associated with or ancillary to the industrial manufacturing or treatment process and can contribute significant amounts of pollutants to navigable waters. Where effluent guidelines require specific control measures, including BMPs or development of a BMP plan, permit writers must include such requirements in permits. In addition, CWA section 402(p)(3)(B)(iii) states that permits for discharges from municipal storm sewers must require controls, including management practices, to reduce the discharge of pollutants. Finally, CWA sections 402(a)(1) and (2) give the permitting authority the ability to include BMPs in permits on a case-by-case basis to carry out the provisions of the CWA.

The NPDES regulations at § 122.44(k) track the statutory provisions cited above. This section of the regulations provides that permits must contain BMPs (when applicable) to control or abate the discharge of pollutants when any of the following are true:

- They are authorized under CWA section 304(e).
- They are authorized under CWA section 402(p) for the control of stormwater discharges.
- Numeric effluent limitations are infeasible.
- The practices are necessary to achieve effluent limitations and standards or carry out the purpose and intent of the CWA.

Circumstances under which numeric effluent limitations might be infeasible include the following:

- Regulating a pollutant for which limited treatability or aquatic impact data are available to allow development of numeric TBELs or WQBELs.
- Regulating discharges when the types of pollutants vary greatly over time.

In addition, a permit writer should consider using BMPs under any of the following circumstances:

- When chemical analyses are inappropriate or impossible.
- When there is a history of leaks and spills or when housekeeping is sloppy.
- When a complex facility lacks data for a pollutant or pollutants.

9.1.2.2 BMPs in NPDES Permits

Permit writers include BMP requirements in permits using two approaches: (1) site-, process-, or pollutant-specific BMPs, or (2) a requirement to develop a BMP plan. Site-, process-, or pollutant-specific BMPs might be appropriate in the case of an individual permit where a permit writer has the opportunity to review the circumstances at the facility. On the other hand, it might not be appropriate to include site-, process-, or pollutant-specific BMPs as conditions in a general permit, a permit for a particularly complex facility, or a permit for a facility with operations not familiar to the permit writer. Instead, complicated facilities and discharges covered under a general permit could be required to develop a BMP plan that requires the permittee to determine appropriate BMPs on the basis of circumstances at its facility.

Specific BMPs

Specific BMPs are designed to address conditions particular to a type of facility or to a specific site, process, or pollutant. Specific BMPs might be used in a permit when

- They are needed to address ancillary activities that could result in the discharge of pollutants to waters of the United States.
- Numeric effluent limitations for a specific process are otherwise infeasible and BMPs serve as effluent limitations for that process.
- They are required to supplement and ensure compliance with effluent limitations in the permit.

To select a specific BMP, the permit writer could

- Review the industry profiles or the specific facility to determine the applicable and appropriate management practices.
- Evaluate whether the BMP would help to achieve effluent limitations or other environmental objectives for that facility.
- Use information from other permits, pollution prevention sources, and EPA guidance documents to identify applicable and appropriate BMPs.

Specific BMPs frequently are required for certain types of dischargers such as concentrated animal feeding operations (CAFOs), combined sewer overflows (CSOs), and stormwater discharges. The use of BMPs in permits for CSOs and stormwater are discussed in sections 9.2.3 and 9.3 below, respectively.

BMP Plans

The *Guidance Manual for Developing Best Management Practices*[9] <www.epa.gov/npdes/pubs/owm0274.pdf> describes the activities and materials at an industrial or municipal facility that are best addressed by BMPs. The manual also describes how BMPs work and gives examples of types of BMPs.

If a permit writer requires a BMP plan, it is the facility's responsibility to develop, implement, and evaluate the success or shortfalls of its own plan. Often, a BMP committee (i.e., a group of individuals within the plant organization) is responsible for developing the BMP plan and assisting the plant management in implementing and updating the BMP plan.

EPA has identified several recommended components of effective BMP plans and detailed each component in the *Guidance Manual for Developing Best Management Practices*. The minimum suggested components of a general BMP plan are presented below:

- General Provisions
  - Name and location of facility.
  - Statement of BMP policy and objective.
  - Review by plant manager.
- Specific Provisions
  - BMP committee.
  - Risk identification and assessment.
  - Reporting of BMP incidents.
  - Materials compatibility.
  - Good housekeeping.
  - Preventive maintenance.
  - Inspections and records.
  - Security.
  - Employee training.

BMP plans used to supplement effluent limitations or to describe how the discharger plans to meet effluent limitations can be submitted to the regulatory agency or be kept on-site and made available to the permitting authority upon request. A general schedule for BMP plan development can be included in the permit (e.g., complete and submit the plan within 6 months of permit issuance and begin implementing the plan within 9 months of permit issuance).

Exhibit 9-1 presents example permit text for a requirement to develop and implement a BMP plan and should be adapted as necessary to reflect conditions at the individual facility.

Exhibit 9-1 Example BMP plan requirement

The following is example text for requiring development and implementation of a BMP plan through an NPDES permit. The text should be crafted and changed as necessary to meet the individual facility's needs and the permitting authority's goals. The bracketed text should be updated to be specific to the permit.

1. Implementation.

[IF A BMP PLAN DOES NOT EXIST:]

The permittee, must develop and implement a best management practices (BMP) plan that achieves the objectives and the specific requirements listed below. A copy of the plan must be submitted to the U.S. Environmental Protection Agency (EPA) **[AND/OR STATE AGENCY]** within six months of the effective date of this permit. The plan must be implemented as soon as possible but no later than nine months from the effective date of the permit. The permittee must update and amend the plan as needed.

[IF A BMP PLAN ALREADY EXISTS:]

The permittee must during the term of this permit operate the facility in accordance with the BMP plan **[CITE EXISTING PLAN]** and in accordance with subsequent amendments to the plan. The permittee must amend the plan to incorporate practices to achieve the objectives and specific requirements listed below, and a copy of the amended plan must be submitted to the U.S. Environmental Protection Agency (EPA) **[AND/OR STATE AGENCY]** within three months of the effective date of this permit. The amended plan must be implemented as soon as possible but not later than six months from the effective date of the permit.

2. Purpose

Through implementation of the BMP plan the permittee must prevent or minimize the generation and the potential for the release of pollutants from the facility to the waters of the United States through normal operations and ancillary activities.

3. Objectives

The permittee must develop and amend the BMP plan consistent with the following objectives for the control of pollutants.

a. The number and quantity of pollutants and the toxicity of effluent generated, discharged, or potentially discharged at the facility must be minimized by the permittee to the extent feasible by managing each influent waste stream in the most appropriate manner.
b. Under the BMP plan, and any Standard Operating Procedures (SOPs) included in the plan, the permittee must ensure proper operation and maintenance of the treatment facility as required by § 122.41(e).
c. The permittee must establish specific objectives for the control of pollutants by conducting the following evaluations.
    1. Each facility component or system must be examined for its waste minimization opportunities and its potential for causing a release of significant amounts of pollutants to waters of the United States because of equipment failure, improper operation, and natural phenomena such as rain or snowfall, etc. The examination must include all normal operations and ancillary activities including material storage areas, plant site runoff, in-plant transfer, process and material handling areas, loading or unloading operations, spillage or leaks, sludge and waste disposal, or drainage from raw material storage. **[NOTE THAT ONLY THE APPLICABLE AREAS SHOULD BE INCLUDED IN THE PREVIOUS LIST.]**
    2. Where experience indicates a reasonable potential for equipment failure (e.g., a tank overflow or leakage), natural condition (e.g., precipitation), or other circumstances that may result in significant amounts of pollutants reaching surface waters, the program should include a prediction of the direction, rate of flow and total quantity of pollutants that could be discharged from the facility as a result of each condition or circumstance.

4. Requirements

The BMP Plan must be consistent with the objectives in the Objectives section above and the general guidance contained in the publication entitled *Guidance Manual for Developing Best Management Practices (BMPs)*, EPA 833-B-93-004, <www.epa.gov/npdes/pubs/owm0274.pdf> or any subsequent revisions to the guidance document. The BMP plan must

a. Be documented in narrative form, must include any necessary plot plans, drawings or maps, and must be developed in accordance with good engineering practices. The BMP plan must be organized and written with the following structure:
    1. Name and location of the facility.
    2. Statement of BMP policy.
    3. Structure, functions, and procedures of the BMP Committee.
    4. Specific management practices and standard operating procedures to achieve the above objectives, including the following:

Exhibit 9-1 Example BMP plan requirement

   a. Modification of equipment, facilities, technology, processes, and procedures,
   b. Reformulation or redesign of products,
   c. Substitution of materials, and
   d. Improvement in management, inventory control, materials handling or general operational phases of the facility.
5. Risk identification and assessment.
6. Reporting of BMP incidents.
7. Materials compatibility.
8. Good housekeeping.
9. Preventative maintenance.
10. Inspections and records.
11. Security.
12. Employee training.

b. Include the following provisions concerning BMP plan review:
   1. Review by plant engineering staff and the plant manager.
   2. Review and endorsement by the permittee's BMP Committee.
   3. A statement that the above reviews have been completed and that the BMP plan fulfills the requirements set forth in this permit. The statement must include the dated signatures of each BMP Committee member as certification of the reviews.

c. Establish specific BMPs to meet the objectives identified in the Objectives section above, addressing each component or system capable of generating or causing a release of significant amounts of pollutants, and identifying specific preventive or remedial measures to be implemented.

d. Establish specific BMPs or other measures that ensure that the following specific requirements are met:
   1. Ensure proper management of solid and hazardous waste in accordance with regulations promulgated under the Resource Conservation and Recovery Act (RCRA). Management practices required under RCRA regulations must be referenced in the BMP plan.
   2. Reflect requirements for Spill Prevention, Control, and Countermeasure (SPCC) plans under Clean Water Act (CWA) section 311 and 40 CFR Part 112 and may incorporate any part of such plans into the BMP plan by reference.
   3. Reflect requirements for stormwater control under CWA section 402(p) and the regulations at 40 CFR 122.26 and 122.44, and otherwise eliminate to the extent practicable, contamination of stormwater runoff.
   4. etc.

[NOTE: SECTION d. ABOVE COULD BE TAILORED TO EACH FACILITY BY THE PERMIT WRITER AND MAY INCLUDE PROCESSES OR AREAS OF THE FACILITY WITH HOUSEKEEPING PROBLEMS, NONCOMPLIANCE, SPILLS/LEAKS, OR OTHER PROBLEMS THAT COULD BE REMEDIED THROUGH A BMP. IF THERE IS A KNOWN SOLUTION TO THE PROBLEM (E.G., MORE FREQUENT INSPECTIONS, PREVENTIVE MAINTENANCE, ETC.), THIS REMEDY COULD ALSO BE INCLUDED AS A PART OF THE BMP PLAN REQUIREMENTS. TO GATHER IDEAS FOR SUCH REQUIREMENTS, THE PERMIT WRITER MAY WANT TO CONTACT THE PERMITTEE, COMPLIANCE PERSONNEL, FACILITY INSPECTORS, OPERATIONS OFFICE PERSONNEL, AND STATE AGENCY COUNTERPARTS. THE PERMIT WRITER MIGHT ALSO WANT TO CHECK REQUIREMENTS IN OTHER PERMITS AND BMP PLANS FOR SIMILAR FACILITIES.]

5. Documentation

The permittee must maintain a copy of the BMP plan at the facility and must make the plan available to EPA **[AND/OR STATE AGENCY]** upon request. All offices of the permittee, which are required to maintain a copy of the NPDES permit, must also maintain a copy of the BMP plan.

6. BMP Plan Modification

The permittee must amend the BMP plan whenever there is a change in the facility, or in the operation of the facility, that materially increases the generation of pollutants or their release or potential release to the receiving waters. The permittee must also amend the plan, as appropriate, when plant operations covered by the BMP plan change. Any such changes to the BMP plan must be consistent with the objectives and specific requirements listed above. All changes in the BMP plan must be reported to EPA **[AND/OR STATE AGENCY]** in writing.

7. Modification for Ineffectiveness

If at any time the BMP plan proves to be ineffective in achieving the general objective of preventing and minimizing the generation of pollutants and their release and potential release to the receiving waters and/or the specific requirements above, the permit and/or the BMP plan must be subject to modification to incorporate revised BMP requirements.

9.1.2.3 Pollution Prevention in BMPs

BMPs are, by their nature, pollution prevention practices. Traditionally, BMPs have focused on good housekeeping measures and good management techniques that attempt to avoid contact between pollutants and water as a result of leaks, spills, and improper waste disposal. However, on the basis of the authority granted under the regulations, BMPs may include a range of pollution prevention options, including production modifications, operational changes, materials substitution, and materials and water conservation.

When developing BMPs, permit writers should be familiar with the fundamental principles of pollution prevention:

- Pollution should be prevented or reduced at the source, whenever feasible (*Reduce*).
- Pollution that cannot be prevented should be reused or recycled in an environmentally safe manner, whenever feasible (*Reuse-Recycle*).
- Pollution that cannot be prevented or recycled should be treated in an environmentally safe manner, whenever feasible (*Treat*).
- Disposal or other release into the environment should be employed only as a last resort and should be conducted in an environmentally safe manner (*Dispose of*).

When writing an NPDES permit, a permit writer who has familiarity with a certain type of processes might identify pollution prevention practices that are not used at a facility and that would help that facility achieve its pollution prevention goals. Where the pollution prevention practices are necessary to carry out the purposes and intent of the CWA, the permit writer may develop BMPs to implement those practices.

9.1.3 Compliance Schedules

The NPDES regulations at § 122.47 allow permit writers to establish schedules of compliance to give permittees additional time to achieve compliance with the CWA and applicable regulations. Schedules developed under this provision must require compliance by the permittee *as soon as possible*, but may not extend the date for final compliance beyond compliance dates established by the CWA. Thus, compliance schedules in permits are not appropriate for every type of permit requirement. Specifically, a permit writer may not establish a compliance schedule in a permit for TBELs because the statutory deadlines for meeting technology standards (i.e., secondary treatment standards and effluent guidelines) have passed. This restriction applies to both existing and new dischargers. Permit writers should note, however, that § 122.29(d)(4) allows a new source or new discharger up to 90 days to *start-up* its pollution control equipment and achieve compliance with its permit conditions (i.e., provides for up to a 90-day period to achieve compliance).

Examples of requirements for which a compliance schedule in an NPDES permit might be appropriate include:

- Pretreatment program development.
- Sludge use and disposal program development and implementation.
- BMP plan development and implementation.
- Effluent limitations derived from new or revised water quality standards.

An EPA Administrator's decision specifically addresses compliance schedules for effluent limitations derived from new or revised water quality standards. In the decision *In the Matter of Star-Kist Caribe, Inc.*, documented in the memorandum *Order Denying Modification Request With Respect to the Administrator's 1990 Decision in Star-Kist Caribe, Inc. (NPDES Appeal No. 88-5)*[10] <www.epa.gov/npdes/pubs/owm0121.pdf>, the EPA Administrator interpreted section 301(b)(1)(C) of the CWA to mean that 1) after July 1, 1977, permits may not contain compliance schedules for effluent limitations based on water quality standards adopted before July 1, 1977, and 2) compliance schedules are allowed for effluent limitations based on standards adopted after that date *only* if the state has clearly indicated in its water quality standards or implementing regulations that it intends to allow them.

In May 2007, the Director of EPA's Office of Wastewater Management issued a memorandum to EPA Region 9 that clarified the requirements of § 122.47 as they relate to WQBELs [see *Compliance Schedules for Water Quality-Based Effluent Limitations in NPDES Permits*[11] <www.epa.gov/npdes/pubs/memo_complianceschedules_may07.pdf>. Permit writers should consider the principles outlined in this memo when assessing whether a compliance schedule for achieving a WQBEL is consistent with the CWA and its implementing regulations and when documenting the basis for a compliance schedule in a permit. Considerations outlined in the memo include the following:

- Demonstrate that the permittee cannot immediately comply with the new effluent limitation on the effective date of the permit.
- Include an enforceable *final* effluent limitation and a date for achievement in the permit.
- Justify and document the *appropriateness* of the compliance schedule; factors relevant to a determination that a compliance schedule is appropriate include how much time the discharger had to meet the WQBEL under prior permit(s), whether there is any need for modifications to treatment facilities, operations, or other measures and, if so, how long it would take to implement such modifications.
- Justify and demonstrate that compliance with the final WQBEL is required *as soon as possible*; factors relevant to a determination that a compliance is required as soon as possible include the steps needed to modify or install treatment facilities, operations, or other measures and the time those steps would take.
- Include an enforceable sequence of events leading to compliance with interim milestones for schedules longer than one year.
- Recognize that a schedule solely to provide time to develop a total maximum daily load (TMDL) or to conduct a use attainability analysis (UAA) is not appropriate.

Many of the principles outlined in the memo could be more generally applied to compliance schedules for requirements other than WQBELs.

9.2 Special Conditions for Municipal Facilities

This section explains several common special conditions that are applicable only to municipal facilities. These conditions reflect requirements for publicly owned treatment works (POTWs) to implement and enforce local pretreatment programs for their industrial users; biosolids (sewage sludge) disposal requirements; CSO requirements; SSO requirements; and municipal separate storm sewer system (MS4) requirements.

9.2.1 The National Pretreatment Program

CWA section 402(b)(8) requires that certain POTWs receiving pollutants from significant industrial sources (subject to CWA section 307(b) standards) establish a pretreatment program to ensure compliance with these standards. The implementing regulations at § 403.8(a) state that:

> Any POTW (or combination of POTWs operated by the same authority) with a total design flow greater than 5 million gallons per day (mgd) and receiving from industrial users pollutants which pass through or interfere with the operation of the POTW or are otherwise subject to pretreatment standards will be required to establish a POTW pretreatment program unless the NPDES state exercises its option to assume local responsibilities as provided in § 403.10(e).

As specified in § 403.8(a), the Regional Administrator or Director of an authorized state may require a POTW with a design flow of 5 mgd or less to develop a POTW pretreatment program. Program development could be determined to be necessary to prevent interference with or pass through of the POTW based on the nature, or volume, of the industrial influent, a history of treatment process upsets and violations of POTW effluent limitation(s), and contamination of municipal sludge.

Since 1978, approximately 1,500 POTWs have been required to develop and implement pretreatment programs through special conditions of NPDES permits. The pretreatment program was developed to control industrial discharges to POTWs and to meet the following objectives:

- To prevent pass through of pollutants.
- To prevent interference with POTW processes, including interference with the use or disposal of municipal sludge.
- To improve opportunities to recycle and reclaim municipal and industrial wastewater and sludges.

The pretreatment program also helps ensure POTW personnel health and safety.

As authorized by the pretreatment regulations at §§ 403.8(c), 403.8(d) and 403.8(e) and the NPDES regulations at § 122.44(j)(2), the requirements to develop and implement a POTW pretreatment program are included as enforceable conditions in the POTW's NPDES permit. NPDES permits drive the development and implementation of pretreatment programs by requiring the following:

- Adequate legal authority.
- Maintenance of an industrial user inventory.
- Development and implementation of local limits.
- Control mechanisms issued to significant industrial users (SIUs).
- Compliance monitoring activities.
- Swift and effective enforcement
- Data management and recordkeeping,
- Reporting to the approval authority (EPA or state).
- Public participation.

Through the NPDES permit, the POTW is required to develop and implement a pretreatment program. The POTW is required to submit an approvable program that meets the requirements in § 403.9(b). A more detailed description of these required program elements is in § 403.8(f). The POTW must have the legal authority enabling it to do the following:

- Deny or condition new or increased contributions of pollutants, or changes in nature of pollutants, to the POTW by industrial users.
- Require compliance with applicable pretreatment standards and requirements by industrial users.
- Control through a permit, order, or similar means the contribution to the POTW by each industrial user to ensure compliance with applicable pretreatment standards and requirements. These control mechanisms must have certain conditions as laid out in § 403.8(f)(1)(iii) and be enforceable.
- Require the development of compliance schedules where necessary by each industrial user for the installation of technology required to meet applicable pretreatment standards and requirements, and submission of all notices and self-monitoring reports to assess and ensure compliance.
- Carry out all inspection, surveillance, and monitoring procedures necessary to determine compliance with applicable pretreatment standards and requirements independent of information submitted by the industrial user (including the authority to enter the premises of the industrial user).
- Obtain remedies for noncompliance (e.g., injunctive relief, penalties).
- Comply with confidentiality requirements.

Further, at a minimum, the POTW must have procedures to do the following:

- Identify and locate all possible industrial users that might be subject to the POTW pretreatment program.
- Identify the character and volume of pollutants contributed to the POTW by the industrial users.
- Notify industrial users of applicable pretreatment standards and applicable requirements under CWA sections 204(b) and 405 and RCRA Subtitles C and D.
- Receive and analyze self-monitoring reports.
- Conduct sampling, inspections and other surveillance activities to determine compliance with applicable pretreatment standards and requirements independent of information supplied by the industrial user.
- Investigate instances of noncompliance.
- Comply with public participation requirements, including annual public notice of industrial users determined to be in significant noncompliance during the previous 12-month period.

Also, as part of the POTW pretreatment program, POTWs must have adequate resources and funding to implement the program, evaluate the need for and, as necessary, develop local limits and develop an enforcement response plan.

The NPDES permit should include the conditions specified in § 403.9, including that the POTW be required to submit the program documentation, detailing the authority and procedures to be implemented, along with other information about the program. The permit will allow the POTW up to one year, from the time when written notification from the approval authority determined the need for a pretreatment program, to develop and submit a program for approval as stated in § 403.8(b). Once the permitting authority reviews and approves the program, the requirement to implement the approved program is then incorporated into the permit.

The permit writer generally incorporates the requirement to develop a pretreatment program at the time of permit reissuance. The requirement, however, may also be incorporated through a modification of the permit if there is *cause*, as defined in detail in § 403.8(e), to make such a modification. The permit writer must follow procedures outlined by § 122.62 related to modifications when including the requirement to develop a pretreatment program in an NPDES permit

During the life of the permit, it might be necessary for the POTW to modify its approved pretreatment program (changes to local limits, changes to the ordinance, and such). The changes can be brought about by the POTW's desire to change the way the program operates, or they can be the result of changes that are necessary to address deficiencies in the program found during inspections or audits done by the permitting authority. Whatever the reason for the modification, the permitting authority must review and approve any modification to the approved program that is considered substantial, as required by § 403.18. All substantial program modifications to the POTW's approved pretreatment program require minor modifications to the NPDES permit and are subject to the procedural requirements in §§ 122.63(g) and 403.18. In addition, incorporating the requirement for a previously approved pretreatment program for the purpose of making the implementation of the program an enforceable part of the permit is also considered a minor modification to the NPDES permit.

The majority of POTWs that need pretreatment program requirements in their permits currently have them in place. In addition, an NPDES state or an EPA region will often designate a pretreatment coordinator to serve as the pretreatment expert to review the annual report from the POTW and recommend any action to be taken. The state or EPA regional pretreatment coordinator is a key resource on pretreatment issues, particularly at the time of NPDES permit reissuance. EPA regions and approved states have developed standard pretreatment development or implementation conditions (with minor modifications made to tailor the conditions to the specific discharger) that are placed in all applicable NPDES permits in that region or state. The permit writer can usually obtain examples of these NPDES pretreatment conditions from the EPA or state pretreatment coordinators. The permit writer might need to update or modify pretreatment implementation language or initiate corrective action related to the pretreatment program.

EPA has developed the Pretreatment Program Website <www.epa.gov/npdes/pretreatment> and prepared a number of guidance manuals for POTWs on how to implement their local pretreatment programs that are accessible through this website. In addition, EPA prepared the *Introduction to the National Pretreatment Program*[12] <www.epa.gov/npdes/pubs/final99.pdf> as a reference for anyone interested in understanding the basics of pretreatment program requirements and to provide a roadmap to additional and more detailed guidance materials for those trying to implement specific elements of the pretreatment program.

Pretreatment program information and monitoring data obtained through the POTW's pretreatment program are useful to the permit writer in identifying possible modifications to the pretreatment program's local limits or procedures, or the need for water quality-based controls. The permit writer should obtain such data with the aid of the pretreatment coordinator. Permits must include conditions requiring a POTW to provide a written technical evaluation of the need to revise local limits under § 403.5(c)(1) following permit issuance or reissuance [§ 122.44(j)(2)(ii)]. In addition, POTWs with a design flow greater than or equal to one mgd and with an approved pretreatment program or required to develop a pretreatment program must sample and analyze their effluent for priority (toxic) pollutants listed in Part 122, Appendix J, Table 2 as part of the permit application process [see § 122.21(j)(4)(iv)]. Those data and information also are useful for determining the need for WQBELs.

9.2.2 Biosolids (Sewage Sludge)

CWA section 405(d) requires that EPA regulate the use and disposal of sewage sludge to protect public health and the environment from any reasonably anticipated adverse effects of these practices. In the CWA, Congress directed EPA to develop technical standards for municipal sludge use and disposal options and enacted strict deadlines for compliance with these standards. Within one year of promulgation of the standards, compliance was required unless construction of new pollution control facilities was necessary, in which case compliance was required within two years.

EPA promulgated Part 503, Standards for the Use or Disposal of Sewage Sludge in 58 *Federal Register* (FR) 9248, February 19, 1993, with amendments in 59 FR 9095, February 19, 1994 and 60 FR 54764, October 25, 1995. These regulations address four sludge use and disposal practices: land application, surface disposal, incineration, and disposal in a municipal solid waste landfill. The standards for each end use and disposal method consist of general requirements, numeric effluent limitations, operational standards, and management practices, as well as monitoring, recordkeeping, and reporting requirements. Unlike technology standards, which are based on the ability of treatment technologies to reduce the level of pollutants, EPA's sewage sludge standards are based on health and environmental risks. Part 503 imposes requirements on four groups:

- Persons who prepare sewage sludge or material derived from sewage sludge.
- Land appliers of sewage sludge.
- Owners/operators of sewage sludge surface disposal sites.
- Owners/operators of sewage sludge incinerators.

Details of that rule are described in *A Plain English Guide to the EPA Part 503 Biosolids Rule*[13] <www.epa.gov/owm/mtb/biosolids/503pe/>.

The risk assessment for the Part 503 rule that governs the land application of biosolids took nearly 10 years to complete and had extensive rigorous review and comment. The risk assessment evaluated and established limitations for a number of pollutants. These limitations are in chapter 4 of *A Guide to the Biosolids Risk Assessments for the EPA Part 503 Rule*[14] <www.epa.gov/owm/mtb/biosolids/503rule/>.

The regulation is largely self-implementing, and anyone who engages in activities covered by the regulation must comply with the appropriate requirements on or before the compliance deadlines. A person who violates Part 503 requirements is subject to administrative, civil, and criminal enforcement actions.

CWA section 405(f) requires the inclusion of sewage sludge use or disposal requirements in any NPDES permit issued to a Treatment Works Treating Domestic Sewage (TWTDS) and authorizes the issuance of sewage sludge-only permits to non-discharging TWTDS. In response, EPA promulgated revisions to the NPDES permit regulations at Parts 122 and 124 in 54 FR 18716, May 2, 1989, to address inclusion of sewage sludge use and disposal standards in NPDES permits and NPDES permit issuance to treatment works that do not have an effluent discharge to waters of the United States, but are involved in sewage sludge use or disposal as preparers, appliers, or owners/operators. TWTDS includes all sewage sludge generators and facilities, such as blenders, that change the quality of sewage sludge.

EPA recognizes that implementation of Part 503 requirements is a source of confusion for permit writers and permittees who might already have NPDES permits with special conditions addressing sewage sludge requirements. EPA has provided several guidance documents to help clarify NPDES permitting expectations, and explain the requirements of Part 503:

- *Part 503 Implementation Guidance*[15] <www.epa.gov/npdes/pubs/owm0237.pdf>.
- *Land Application of Sewage Sludge—A Guide for Land Appliers on the Requirements of the Federal Standards for the Use or Disposal of Sewage Sludge Management in 40 CFR Part 503*[16] <www.epa.gov/npdes/pubs/sludge.pdf>.
- *Surface Disposal of Sewage Sludge—A Guide for Owners/Operators of Surface Disposal Facilities on the Monitoring, Recordkeeping, and Reporting Requirements of the Federal Standards for the Use or Disposal of Sewage Sludge in 40 CFR Part 503*[17] <No Link–see the endnote for ordering instructions>.
- *Preparing Sewage Sludge for Land Application or Surface Disposal—A Guide for Preparers of Sewage Sludge on the Monitoring, Record Keeping, and Reporting Requirements of the Federal Standards for the Use or Disposal of Sewage Sludge in 40 CFR Part 503*[18] <No Link–see the endnote for ordering instructions>.
- *Domestic Septage Regulatory Guidance, A Guide to the EPA 503 Rule*[19] <www.epa.gov/npdes/pubs/owm0026.pdf>.
- *Control of Pathogens and Vector Attraction in Sewage Sludge*[20] <www.epa.gov/nrmrl/pubs/625r92013/625R92013.pdf>.

The permit writer should refer to the *Part 503 Implementation Guidance* and EPA Region and state guidelines or policies for instructions on how to implement the applicable Part 503 standards into the permit. The permit writer will need to determine the type of sewage sludge use or disposal practice(s) used by the discharger and apply the appropriate Part 503 standards. In general, conditions will need to be established to address the following:

- Pollutant concentrations or loading rates.
- Operational standards (such as pathogen and vector attraction reduction requirements for land application and surface disposal and total hydrocarbons (THC) concentrations for incinerators).
- Management practices (e.g., siting restrictions, design requirements, operating practices).
- Monitoring requirements (e.g., pollutants to be monitored, sampling locations, frequency, and sample collection and analytical methods).

- Recordkeeping requirements.
- Reporting requirements (e.g., contents of reports and frequency or due dates for submission of reports).
- General requirements (e.g., specific notification requirements before land application, submission of closure and post closure plan for surface disposal sites).

In addition to any specific applicable Part 503 standards, three boilerplate conditions must be written in the NPDES permit where applicable. These consist of the following:

- Text requiring the POTW/TWTDS to comply with all existing requirements for sewage sludge use and disposal, including the Part 503 standards [see § 122.44(b)(2)].
- A reopener clause, which authorizes reopening a permit to include technical standards if the technical standards are more stringent or more comprehensive than the conditions in the permit [see § 122.44(c)].
- A notification provision requiring the permittee to give notice to the permitting authority when a significant change in the sewage sludge use or disposal practice occurs (or is planned) [see standard conditions in § 122.41(l)(1)(iii)].

If permit conditions based on existing regulations are insufficient to protect public health and the environment from adverse effects that could occur from toxic pollutants in sewage sludge, permit conditions should be developed on a case-by-case basis using best professional judgment (BPJ) to fulfill the statutory requirement. The *Part 503 Implementation Guidance* contains information to assist permit writers in developing effluent limitations and management practice requirements on a case-by-case basis to protect public health and the environment from adverse effects that could occur from toxic pollutants in sewage sludge. For more information on biosolids, see section 2.3.1.3 of this manual and the Biosolids Website <www.epa.gov/owm/mtb/biosolids/index.htm>

9.2.3 Combined Sewer Overflows (CSOs)

Combined sewer systems were designed and built in the 19th and early 20th centuries to collect sanitary and industrial wastewater and stormwater runoff. During dry weather, combined sewers carry sanitary wastes and industrial wastewater to a treatment plant. In periods of heavy rainfall, however, stormwater is combined with untreated wastewater, which can overflow and discharge directly to a waterbody without being treated. These overflows are called combined sewer overflows (CSOs).

EPA published a CSO Control Policy in 59 FR 18688, April 19, 1994. That policy represents a comprehensive national strategy to ensure that municipalities, permitting authorities, water quality standards authorities, and the public engage in a comprehensive and coordinated planning effort to achieve cost-effective CSO controls that ultimately meet appropriate health and environmental objectives.

The CSO Control Policy includes expectations for NPDES permitting authorities. In general, EPA envisioned a phased permit approach, including initial requirements to implement Nine Minimum CSO Controls (NMC) and develop a Long-Term CSO Control Plan (LTCP), followed by requirements to implement the controls in the approved LTCP. The Wet Weather Water Quality Act of 2000 amended the CWA to add section 402(q), which required that CSO permits be issued in conformance with the CSO Control Policy.

CSOs are point source discharges subject to both the technology-based requirements of the CWA and applicable state water quality standards. Under the CWA, CSOs must comply with Best Available Technology Economically Achievable (BAT) for nonconventional and toxic pollutants and Best Conventional Technology (BCT) for conventional pollutants. However, there are no promulgated BAT or BCT limitations in effluent guidelines for CSOs. As a result, permit writers must use BPJ in developing technology-based permit requirements for controlling CSOs. Permit conditions also must achieve compliance with applicable water quality standards.

The 1994 CSO Control Policy contains the recommended approach for developing and issuing NPDES permits to control CSOs. In addition, EPA has developed the following CSO guidance documents to help permit writers and permittees implement the CSO Control Policy:

- *Combined Sewer Overflows–Guidance for Long-Term Control Plan*[21] <www.epa.gov/npdes/pubs/owm0272.pdf>.
- *Combined Sewer Overflows–Guidance for Nine Minimum Controls*[22] <www.epa.gov/npdes/pubs/owm0030.pdf>.
- *Combined Sewer Overflows–Guidance for Screening and Ranking*[23] <www.epa.gov/npdes/cso>.
- *Combined Sewer Overflows–Guidance for Monitoring and Modeling*[24] <www.epa.gov/npdes/pubs/sewer.pdf>.
- *Combined Sewer Overflows–Guidance for Financial Capability Assessment and Schedule Development*[25] <www.epa.gov/npdes/pubs/csofc.pdf>.
- *Combined Sewer Overflows–Guidance for Funding Options*[26] <www.epa.gov/npdes/pubs/owm0249.pdf>.
- *Combined Sewer Overflows–Guidance for Permit Writers*[27] <www.epa.gov/npdes/cso>.
- *Combined Sewer Overflows–Guidance: Coordinating Combined Sewer Overflow Long-Term Planning with Water Quality Standards Reviews*[28] <www.epa.gov/npdes/pubs/wqs_guide_final.pdf>.

Combined Sewer Overflows–Guidance for Permit Writers[24] contains guidance and example permit language that permit writers can use. Controlling CSOs typically requires substantial long-term planning, construction, financing and continuous reassessment; therefore, the implementation of CSO controls will probably occur over several permit cycles. The guidance explains a phased permitting approach to CSOs. Exhibit 9-2 depicts this phased permitting approach and the types of permit conditions that should be developed for each phase.

Exhibit 9-2 Categories of CSO permitting conditions

NPDES permit	Phase I	Phase II	Post phase II
A. Technology-based	• NMC, at a minimum	• NMC, at a minimum	• NMC, at a minimum
B. Water Quality-based	• Narrative	• Narrative + performance-based standards	• Narrative + performance-based standards + numeric WQBELs (as appropriate)
C. Monitoring	• Characterization, monitoring, and modeling of CSS	• Monitoring to evaluate water quality impacts • Monitoring to determine effectiveness of CSO controls.	• Post-construction compliance monitoring
D. Reporting	• Documentation of NMC implementation • Interim LTCP deliverables.	• Implementation of CSO controls (both NMC and long-term controls)	• Report results of post-construction compliance monitoring
E. Special conditions	• Prohibition of dry weather overflows (DWO) • Development of LTCP	• Prohibition of DWO • Implementation of LTCP • Reopener clause for water quality standards violations • Sensitive area reassessment	• Prohibition of DWO • Reopener clause for water quality standards violations

Depending on the permittee's situation, a permit may contain both Phase I and Phase II elements. Phase I permits require demonstration of implementation of the NMC, shown in Exhibit 9-3.

Exhibit 9-3 Nine minimum CSO controls

1.	Proper operation and regular maintenance programs for the sewer system and the CSOs
2.	Maximum use of the collection system for storage
3.	Review and modification of pretreatment requirements to ensure that CSO impacts are minimized
4.	Maximization of flow to the POTW for treatment
5.	Prohibition of CSOs during dry weather
6.	Control of solid and floatable materials in CSOs
7.	Establishment of pollution prevention programs
8.	Public notification to ensure that the public receives adequate notification of CSO occurrences and CSO impacts
9.	Monitoring to effectively characterize CSO impacts and the efficacy of CSO controls

In the Phase I permit issued/modified to reflect the CSO Control Policy, the NPDES authority should at least require permittees to

- Immediately implement BAT/BCT, which at a minimum includes the NMC, as determined on a BPJ basis by the permitting authority.
- Develop and submit a report documenting the implementation of the NMC within 2 years of permit issuance/modification.

- Comply with applicable water quality standards, no later than the date allowed under the state's water quality standards expressed in the form of a narrative limitation.
- Develop and submit, consistent with the CSO Control Policy and based on a schedule in an appropriate enforceable mechanism, an LTCP, as soon as practicable, but generally within 2 years after the effective date of the permit issuance/modification. Permitting authorities may establish a longer timetable for completion of the long-term CSO control plan on a case-by-case basis to account for site-specific factors that could influence the complexity of the planning process. Exhibit 9-4 shows the minimum elements of the LTCP.

Exhibit 9-4 Elements of the long-term CSO control plan

1. Characterization, monitoring, and modeling of the combined sewer system
2. Public participation
3. Consideration of sensitive areas
4. Evaluation of alternatives
5. Cost/performance considerations
6. Operational plan
7. Maximizing treatment at the existing POTW treatment plant
8. Implementation schedule
9. Post-construction compliance monitoring program.

Phase II permits require the implementation of an LTCP. The Phase II permit should contain the following:

- Requirements to implement the technology-based controls including the NMC determined on a BPJ basis.
- Narrative requirements that ensure that the selected CSO controls are implemented, operated and maintained as described in the LTCP.
- Water quality-based effluent limits under §§ 122.44(d)(1) and 122.44(k), requiring, at a minimum, compliance with, no later than the date allowed under the state's water quality standards, the numeric performance standards for the selected CSO controls, based on average design conditions specifying at least one of the following:
  - A maximum number of overflow events per year for specified design conditions consistent with II.C.4.a.i of the CSO Control Policy.
  - A minimum percentage capture of combined sewage by volume for treatment under specified design conditions consistent with II.C.4.a.ii of the CSO Control Policy.
  - A minimum removal of the mass of pollutants discharged for specified design conditions consistent with II.C.4.a.iii of CSO Control Policy.
  - Performance standards and requirements that are consistent with II.C.4.b of the CSO Control Policy.
- A requirement to implement, with an established schedule, the approved post-construction water quality assessment program including requirements to monitor and collect sufficient information to demonstrate compliance with water quality standards and protection of designated uses as well as to determine the effectiveness of CSO controls.

- A requirement to reassess overflows to sensitive areas in those cases where elimination or relocation of the overflow is not physically possible and economically achievable.
- Conditions establishing requirements for maximizing the treatment of wet-weather flows at the POTW, as appropriate, consistent with section II.C.7. of the CSO Policy.
- A reopener clause authorizing the NPDES authority to reopen and modify the permit upon determination that the CSO controls fail to meet water quality standards or protect designated uses.

Reviewing the permittee's LTCP and consultations with other staff involved in the CSO control process and the permittee are important steps in the process of determining the appropriate Phase II permit conditions. Water quality-based controls in phase II generally are expressed as narrative requirements and performance standards for the combined sewer system. Finally, post Phase II permit conditions would address continued implementation of the NMC, long-term CSO controls, and post-construction compliance monitoring. There may also be numeric WQBELs when there are sufficient data to support their development.

LTCP implementation schedules were expected to include project milestones and a financing plan for design and construction of necessary controls as soon as practicable. The CSO Control Policy expected permitting authorities to undertake the following:

- Review and revise, as appropriate, state CSO permitting strategies developed in response to the National CSO Control Strategy.
- Develop and issue permits requiring CSO communities to immediately implement the NMC and document their implementation and develop and implement an LTCP.
- Promote coordination among the CSO community, the water quality standards authority, and the general public through LTCP development and implementation.
- Evaluate water pollution control needs on a watershed basis and coordinate CSO control with the control of other point and nonpoint sources of pollution.
- Recognize that it might be difficult for some small communities to meet all the formal elements of LTCP development, and that compliance with the NMC and a reduced scope LTCP might be sufficient.
- Consider sensitive areas, use impairment, and a CSO community's financial capability in the review and approval of implementation schedules.

Communities must develop and implement LTCPs to meet water quality standards, including the designated uses and criteria to protect those uses for waterbodies that receive CSO discharges. The CSO Control Policy recognized that substantial coordination and agreement among the permitting authority, the water quality standards authority, the public, and the CSO community would be required to accomplish this objective. The CSO Control Policy also recognized that the development of the LTCP should be coordinated with the review and appropriate revision of water quality standards and their implementation procedures.

In developing permit requirements to meet technology-based requirements and applicable state water quality standards, the permit writer, in conjunction with staff involved in water quality standards and the permittee, should identify the appropriate site-specific considerations that will determine the CSO conditions to be established in the permit. EPA believes that the following information will be particularly relevant in developing the appropriate conditions:

- CSO Discharge
  - Flow, frequency, and duration of the CSO discharge.
  - Available effluent characterization data on the CSO discharge.
  - Available information and data on the impacts of the CSO discharge(s) (e.g., CWA section 305(b) reports, ambient survey data, fish kills, CWA section 303(d) lists of impaired waters).
  - Compliance history of the CSO owner, including performance and reliability of any existing CSO controls.
  - Current NPDES permit and NPDES permit application.
  - Facility planning information from the permittee that addresses CSOs.

- Technologies
  - Performance data (either from the manufacturer or from other applications) for various CSO technologies that may be employed, including equipment efficiency and reliability.
  - Cost information associated with both the installation, operation and maintenance of CSO technologies.
  - Reference materials on various types of CSO.

For more information on CSOs, see section 2.3.1.4 of this manual and the Combined Sewer Overflows Website <www.epa.gov/npdes/cso>.

9.2.4 Sanitary Sewer Overflows (SSOs)

EPA's *Report to Congress on the Impacts and Control of CSOs and SSOs*[29] <www.epa.gov/npdes/csossoreport2004> shows that NPDES permit requirements establishing clear reporting, recordkeeping and third party notification of overflows from municipal sewage collection systems, as well as clear requirements to properly operate and maintain the collection system, are critical to effective program implementation. NPDES authorities should be improving NPDES permit requirements for SSOs and sanitary sewer collection systems, which could lead to improved performance of municipal sanitary sewer collection systems and improved public notice for SSO events.

The NPDES regulations provide standard conditions that are to be in NPDES permits for POTWs as discussed in Chapter 10 of this manual. Standard conditions in a permit for a POTW apply to portions of the collection system for which the permittee has ownership or has operational control. When reissued, permits for POTW discharges should clarify how key standard permit conditions apply to SSOs and sanitary sewer collection systems. On August 20, 2007, EPA circulated a draft fact sheet, NPDES Permit Requirements for Municipal Sanitary Sewer Collection Systems and SSOs <www.epa.gov/npdes/pubs/sso_fact_sheet_model_permit_cond.pdf>, which explains the ways NPDES permitting authorities should be improving implementation of NPDES permit requirements to address SSOs and sanitary sewer collection systems.

The draft fact sheet indicates that clarifications should address the particular application of standard permit conditions to SSOs and municipal sanitary sewer collection systems as discussed below.

- **Immediate reporting.** Permits should clarify that the permittee is required to notify the NPDES authority of an overflow that could endanger health or the environment from portions of the collection system over which the permittee has ownership or operational control as soon as practicable but within 24 hours of the time the permittee becomes aware of the overflow. [See § 122.41(l)(6).]
- **Written reports**. Permits should clarify that the permittee is required to provide the NPDES authority a written report within 5 days of the time it became aware of any overflow that is subject to the immediate reporting provision. [See § 122.41(l)(6)(i).] In addition, permits should clarify that any overflow that is not immediately reported as indicated above, should be reported in the discharge monitoring report. [See § 122.41(l)(7).]
- **Third party notice.** Permits should establish a process for requiring the permittee or the NPDES authority to notify specified third parties of overflows that could endanger health because of a likelihood of human exposure; or unanticipated bypass and upset that exceeds any effluent limitation in the permit or that could endanger health because of a likelihood of human exposure. Permits should clarify that the permittee is required to develop, in consultation with appropriate authorities at the local, county, or state level (or any combination), a plan that describes how, under various overflow (and unanticipated bypass and upset) scenarios, the public, and other entities, would be notified of overflows that may endanger health. The plan should identify all overflows that would be reported, to whom they should be reported, the specific information that would be reported, a description of lines of communication, and the identities of responsible officials. [See § 122.41(l)(6).]
- **Recordkeeping**. Permits should clarify that the permittee is required to keep records of overflows. Clarified permit language for recordkeeping should require the permittee to retain the reports submitted to the NPDES authority and other appropriate reports that could include work orders associated with investigation of system problems related to an overflow, that describes the steps taken or planned to reduce, eliminate, and prevent reoccurrence of the overflow. [See § 122.41(j).]
- **Capacity, management, operation and maintenance programs.** Permits should clarify requirements for proper operation and maintenance of the collection system. [See §§ 122.41(d) and 122.41(e).]. This may include requiring the development and implementation of capacity, management, operation and maintenance (CMOM) programs. EPA's Region 4 has developed materials and guidance that can help a municipality with its CMOM program on the Management, Operation and Maintenance (MOM) Programs Project Website <www.epa.gov/region4/water/wpeb/momproject/>. The CMOM program may use a process for self-assessment and information management techniques for ongoing program improvement and may develop and implement emergency response procedures to overflows. In addition, the CMOM permit condition may specify appropriate documentation requirements, including the following:
  - CMOM program summary. Permittees may be required to develop a written summary of their CMOM programs, which would be available to the NPDES authority and public on request. The program summary would give an overview of the management program and summarize major implementation activities.

- Program audit report. Permittees may be required to conduct comprehensive audits of their programs during the permit cycle, and submit a copy of the audit report to the NPDES authority with the application for permit renewal. EPA's Sanitary Sewer Overflow Toolbox Website <www.epa.gov/npdes/sso/ssotoolbox> provides information on CMOM.
- System evaluation and capacity assurance plan. Capacity assurance refers to a process to identify, characterize and address hydraulic deficiencies in a sanitary sewer collection system. The permit may require the permittee to implement a program to assess the current capacity of the collection system and treatment facilities that they own or over which they have operational control to ensure that discharges from unauthorized locations do not occur. Where peak flow conditions contribute to an SSO discharge or to noncompliance at a treatment plant, the permittee may be required to prepare and implement a system evaluation and capacity assurance plan. In some instances, the permittee may already be under an enforceable obligation and schedule, in which case this permit provision would be redundant and, thus, unnecessary.

Section 2.3.1.5 of this manual and EPA's Sanitary Sewer Overflows Website <www.epa.gov/npdes/sso> provide more information on SSOs.

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U.S. Environmental Protection Agency

NPDES Permit Writers' Manual

U.S. Environmental Protection Agency
Office of Wastewater Management, Water Permits Division
State and Regional Branch

EPA-833-K-10-001 • September 2010

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United States
Environmental Protection
Agency

Office of Water
Washington, DC

United States Environmental Protection Agency

National Pollutant Discharge Elimination System (NPDES) Permit Writers' Manual

This guidance was developed by staff within the U.S. Environmental Protection Agency's (EPA's) Office of Wastewater Management and addresses development of wastewater discharge permits under the National Pollutant Discharge Elimination System (NPDES). NPDES permit development is governed by existing requirements of the Clean Water Act (CWA) and the EPA NPDES implementing regulations. CWA provisions and regulations contain legally binding requirements. This document does not substitute for those provisions or regulations. Recommendations in this guidance are not binding; the permitting authority may consider other approaches consistent with the CWA and EPA regulations. When EPA makes a permitting decision, it will make each decision on a case-by-case basis and will be guided by the applicable requirements of the CWA and implementing regulations, taking into account comments and information presented at that time by interested persons regarding the appropriateness of applying these recommendations to the situation. This guidance incorporates, and does not modify, existing EPA policy and guidance on developing NPDES permits. EPA may change this guidance in the future.

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EPA-833-K-10-001
September 2010

Acknowledgements

David Hair and Pravin Rana, *United States Environmental Protection Agency (EPA), Office of Water, Office of Wastewater Management, Water Permits Division, Washington, DC*, were the team leaders for the development and production of this manual.

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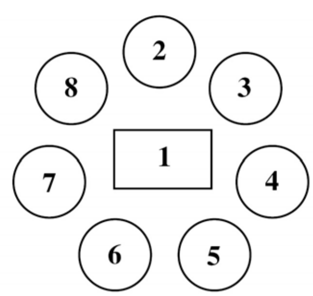
5. Incidental Vessel Discharges—Smithsonian Environmental Research Center, National Ballast Information Clearinghouse
6. Non-Municipal (Industrial)—EPA
7. Construction Stormwater—Barry Tonning, Tetra Tech, Inc.
8. Combined Sewer Overflow—EPA



Contents

Exhibits

Introduction to the Manual

This manual reviews the statutory and regulatory framework of the National Pollutant Discharge Elimination System (NPDES) program and examines technical considerations for developing NPDES permits for wastewater discharges. The manual is designed, primarily, for new permit writers becoming acquainted with the NPDES program and the process of permit writing, but can also serve as a reference for experienced permit writers or anyone interested in learning about the legal and technical aspects of developing NPDES permits. This manual replaces the *1996 U.S. EPA NPDES Permit Writers' Manual*[1] <www.epa.gov/npdes/pubs/owm0243.pdf>, which updated the *1993 Training Manual for NPDES Permit Writers*[2] <www.epa.gov/npdes/pubs/owm0339.pdf>.

To assist the reader, acronyms and abbreviations are defined for the first use in each chapter and in Appendix A of the manual. Endnotes are provided at the end of each chapter.

Purpose of this Manual

The purpose of this *NPDES Permit Writers' Manual* (manual) is to provide a general reference for permitting authorities that outlines and explains the core elements of the NPDES permit program. The core elements form the foundation of the NPDES program on which guidance for specific areas of the program (e.g., stormwater, concentrated animal feeding operations) can be built. While the guidance for these core program areas will be applicable in many cases, the U.S. Environmental Protection Agency (EPA) recognizes that each EPA Regional Office or authorized state, territory, or tribe (hereafter *state*) will tailor specific aspects of its NPDES permitting procedures to address state and local laws and site-specific concerns and conditions.

The specific objectives and functions of this manual are as follows:

- Provide an overview of the scope and the statutory and regulatory framework of the NPDES program.
- Describe the essential components of a permit and provide an overview of the permitting process.
- Describe the different types of effluent limitations and the legal and technical considerations involved in developing effluent limitations.
- Describe the legal and technical considerations involved in developing other permit conditions including
  - Monitoring and reporting requirements.
  - Special conditions.
  - Standard conditions.
- Describe other permitting considerations including
  - Variances.
  - Anti-backsliding.
  - Other applicable statutes.

- Explain the administrative process for issuing, modifying, revoking and terminating NPDES permits.

This manual is not intended to be a standalone reference document. Rather, it establishes the framework for NPDES permit development and should be supplemented, where necessary, by additional EPA and state regulations, policy, and detailed guidance applicable to specific types of dischargers and circumstances. To that end, this manual identifies and references relevant regulations, policy, and other guidance documents throughout the text.

Publications Referenced

This manual provides links to publications available online that supplement the information in the manual. All documents available electronically were accessed and available as of the date of this manual's publication. Some documents are not available in an electronic format. In those instances, readers should check the following sources to determine the availability of and to obtain printed copies of the documents:

- Office of Water Resource Center (OWRC) <www.epa.gov/safewater/resource/>
  OWRC is a contractor-operated facility providing document delivery, information/referral, and reference services to public users and EPA staff interested in Office of Water Program information
  phone: 202-566-1729 or 800-832-7828, fax: 202-566-1736, e-mail: <center.water-resource@epa.gov>.
- EPA Library Services and Repositories <www.epa.gov/natlibra/libraries.htm>
  EPA's library services and repositories provide access to information about the environment and related scientific, technical, management, and policy information. Library services <www.epa.gov/natlibra/library_services.html> are delivered through the National Library Network <www.epa.gov/natlibra/index.html>.
- National Service Center for Environmental Publications (NSCEP) <www.epa.gov/ncepihom/>
  NSCEP, formerly NCEPI, maintains and distributes EPA publications in hardcopy, CD ROM and other multimedia formats. The publication inventory includes more than 7,000 titles
  phone: 513-489-8190 or 800-490-9198, fax: 513-489-8695, e-mail: ncepimal@one.net.
- National Technical Information Service (NTIS) <www.ntis.gov/>
  NTIS is the largest central resource for government-funded scientific, technical, engineering, and business related information covering more than 350 subject areas from more than 200 federal agencies
  phone: 703-605-6050 or 888-584-8332, fax: 703-605-6900, e-mail: customerservice@ntis.gov.

Legislative and Regulatory Citations

There are a number of different conventions used to cite legislation and regulations. In this manual, the following conventions have been used:

- When citing the *United States Code*, the abbreviation U.S.C. is used. The abbreviation is preceded by the Title of the U.S.C. and then followed by the section number.
  Example: 16 U.S.C. 1531 *et seq*. and 33 U.S.C. §§ 1251-1387.

- When citing the Clean Water Act, the abbreviation CWA is used. The abbreviation is followed by the word *section* and then the section number.
  Example: CWA section 402 and CWA section 402(o).
- When citing the *Code of Federal Regulations* (CFR), the convention depends on the location of the reference. For first references, the abbreviation CFR is preceded by the title number of the CFR and followed either by the word *Part* (if it is a part—a whole number) or the number of the subsection (if it is a subpart/subsection). For subsequent references, the title and CFR are omitted and just the word *Part* or the section symbol (§) is used.
  Example: First citation: 40 CFR Part 136 or 40 CFR 122.44
  Subsequent citations: Part 136 or § 122.44.

Almost all the regulatory citations in this manual are for Title 40 of the CFR (with the exception of the other federal laws referenced in section 11.1 of this manual). Any other Titles are explicitly referenced and in the format for the first regulatory citation (e.g., 50 CFR Part 402).

Electronic NPDES Information

Websites and electronically stored publications and data are available to help permit writers draft NPDES permits. Tools have been created to assist permit writers with specific aspects of permit development and are discussed in their respective sections. The electronic tools listed below apply to all aspects of permit development and serve as valuable references for the permit writer.

NPDES Website and Resources

The Water Permits Division (WPD) within the EPA Office of Water (OW), Office of Wastewater Management, has developed a comprehensive NPDES Website <www.epa.gov/npdes> with technical and regulatory information about the NPDES permit program, information on related programs and initiatives, and documents published by WPD. Where applicable, this manual references the NPDES Website and provides links to relevant documents on that site. This manual also references other EPA and non-EPA websites that contain information that might be helpful to NPDES permit writers. Note, however, that EPA is not responsible for information provided on websites outside the EPA Website <www.epa.gov>.

WPD also has prepared several websites and other resources to help permit writers draft permits. This manual references those websites and resources in the appropriate section of this manual.

Electronic Permitting Tools

Many EPA Regions and authorized states have developed tools to help them manage the permit issuance process. Electronic permitting tools range from spreadsheets and word processing applications to sophisticated Web-based systems that enable permitting authorities to manage their entire environmental program. For example, some states have built systems that enable dischargers to electronically sign and submit discharge reports; create, track, and store permit documents; and manage enforcement, compliance, and inspections related to permits. As technologies continue to evolve, many permitting authorities are likely to begin using more information technology applications to manage the process of permitting.

ICIS-NPDES

Together with OW, the Office of Enforcement and Compliance Assurance (OECA) is responsible for oversight of implementation of the NPDES program. OW is responsible for the NPDES implementing regulations and oversight of permit issuance by states and EPA Regions. OECA, along with its regional, state, tribal and local counterparts, is responsible for tracking and maintaining enforcement and compliance activities, monitoring and enforcement and compliance status of the regulated community, and reviewing and evaluating program performance. OECA also maintains national data systems to support program management and oversight of the NPDES program.

The Permit Compliance System (PCS), one of two national NPDES electronic databases, supports the management and oversight of the NPDES program. Since the last modernization of PCS in 1985, the NPDES program has evolved significantly to include additional program requirements, such as the NPDES program for stormwater and implementation of the Combined Sewer Overflow Control Policy. Because of limitations to PCS, OECA is working to phase out this system and move to a more modern data management system described below.

The Integrated Compliance Information System for NPDES permits (ICIS-NPDES) <https://icis.epa.gov/icis>, the successor to PCS, provides an updated system that enables national program management and oversight activities such as

- Permit tracking and management.
- Compliance monitoring.
- NPDES program management.
- Enforcement actions.

ICIS-NPDES is a Web-based system with an electronic database capable of handling the large amount of data generated by and about the NPDES program. Section 11.5.1.1 of this manual provides more information on ICIS-NPDES as it relates to NPDES permit compliance.

Hyperlinks in this Document

Where a website provides supplementary information or is referenced in this manual, the actual site or higher level site address appears in the symbols < > so that readers will have a reference to the address even in a printed version of this document. In the electronic version of the manual, the text in carats is also the hyperlink to the referenced website. Care has been taken to provide the correct Web addresses and hyperlinks; however, these references can change or become outdated after this manual's publication.

[1] U.S. Environmental Protection Agency. 1996. *U.S. EPA NPDES Permit Writers' Manual*. EPA-833-B-96-003. U.S. Environmental Protection Agency, Office of Water, Washington, DC. <www.epa.gov/npdes/pubs/owm0243.pdf>. Separate sections of this document are also available on the NPDES Website by going to <www.epa.gov/npdes>, clicking on Publications and entering NPDES Permit Writers' Manual in the Search box.

[2] U.S. Environmental Protection Agency. 1993. *Training Manual for NPDES Permit Writers*. EPA-833-B-93-003. U.S. Environmental Protection Agency, Office of Wastewater Management, Washington, DC. <www.epa.gov/npdes/pubs/owm0339.pdf>.

United States
Environmental Protection
Agency

Office Of Water
(EN-336)

EPA/505/2-90-001
PB91-127415
March 1991

EPA

Technical Support Document For Water Quality-based Toxics Control

3. EFFLUENT CHARACTERIZATION

3.1 INTRODUCTION

Once the applicable designated uses and water quality criteria for a waterbody are determined, the effluent must be characterized and the permitting authority must determine the need for permit limits to control the discharge. The purpose of effluent characterization is to determine whether the discharge causes, has the reasonable potential to cause, or contributes to an excursion of numeric or narrative water quality criteria. **Once the permitting authority determines that a discharge causes, has the reasonable potential to cause, or contributes to the excursion of water quality criteria, the permitting authority must develop permit limits that will control the discharge.** At a minimum, the permitting authority must make this determination at each permit reissuance. The effluent characterization procedures described in the following sections apply only to the water quality-based approach, not to end-of-the-pipe technology-based controls.

Although many waterbodies receive discharges from only single point sources, permitting authorities will also occasionally encounter receiving waters where several dischargers are in close proximity. In such situations, the permitting authority may find that each discharger alone does not cause, have the reasonable potential to cause, or contribute to an excursion above water quality criteria. Yet, the dischargers may collectively cause, have the reasonable potential to cause, or contribute to an excursion. **Under these circumstances, limits must be developed for each discharger to protect against collective excursions of applicable water quality standards consistent with the Environmental Protection Agency's (EPA) existing regulations in 40 *CFR* 122.44(d)(1)(ii) for controlling multiple discharges.** The terms "cause," "reasonable potential to cause," and "contribute to" are the terms used in the National Pollutant Discharge Elimination System (NPDES) regulations for conditions under which water quality-based limits are required. Permitting authorities are required to consider each of these concepts when performing effluent characterizations.

This chapter is divided into two parts: Section 3.2, Determining the Need for Permit Limits Without Effluent Data, and Section 3.3, Determining the Need for Permit Limits With Effluent Data. Section 3.3 includes effluent characterization for whole effluent toxicity and for specific chemicals (including those for human health protection) and is based on the cumulative experience gained by EPA, States, publicly owned treatment works (POTWs), and industry when implementing the water quality-based approach to toxics control. The effluent bioconcentration evaluation procedures described in the section on human health are currently draft and are subject to further validation before being used. Until the procedures are fully developed, reviewed, and finalized, permitting authorities should not use them to characterize effluents.

3.1.1 NPDES Regulation Requirements

Effluent characterization is an essential step in determining the need for an NPDES permit limit. NPDES regulations under 40 *CFR* 122.44(d)(1) specify the minimum requirements and general types of analyses necessary for establishing permit limits. Each of these regulations is described below.

40 *CFR* 122.44(d)(1)(ii)

> When determining whether a discharge causes, has the reasonable potential to cause, or contributes to an in-stream excursion above a narrative or numeric criteria within a State water quality standard, the permitting authority shall use procedures which account for existing controls on point and nonpoint sources of pollution, the variability of the pollutant or pollutant parameter in the effluent, the sensitivity of the species to toxicity testing (when evaluating whole effluent toxicity), and where appropriate, the dilution of the effluent in the receiving water.

This regulation requires at a minimum the consideration of each of these elements in determining the need for a limit.

40 *CFR* 122.44(d)(1)(iii)

> When the permitting authority determines, using the procedures in paragraph (d)(1)(ii) of this section, that a discharge causes, has the reasonable potential to cause, or contributes to an in-stream excursion above the allowable ambient concentration of a State numeric criteria within a State water quality standard for an individual pollutant, the permit must contain effluent limits for that pollutant.

Under this regulation, permitting authorities need to investigate for the existence of pollutants in effluents if there is a numeric water quality criterion for that pollutant and to implement limits for those pollutants where necessary.

40 *CFR* 122.44(d)(1)(iv)

> When the permitting authority determines, using the procedures in paragraph (d)(1)(ii) of this section, that a discharge causes, has the reasonable potential to cause, or contributes to an in-stream excursion above the numeric criterion for whole effluent toxicity, the permit must contain effluent limits for whole effluent toxicity.

Under this regulation, permitting authorities need to investigate for the existence of whole effluent toxicity in effluents if there is a numeric water quality criterion for that parameter and to implement whole effluent toxicity limits where necessary.

40 *CFR* 122.44(d)(1)(v)

> Except as provided in this subparagraph, when the permitting authority determines, using the procedures in paragraph (d)(1)(ii) of this section, toxicity testing data, or other information, that a discharge causes, has the reasonable potential to cause, or contributes to an in-stream excursion above a narrative criterion within an applicable State water quality standard, the permit must contain effluent limits for whole effluent toxicity. Limits on whole effluent toxicity are not necessary where the permitting authority demonstrates in the fact sheet or statement of basis of the NPDES permit, using the procedures in paragraph (d)(1)(ii) of this section, that chemical-specific limits for the effluent are sufficient to attain and maintain applicable numeric and narrative State water quality standards.

Under this regulation, permitting authorities need to investigate for the existence of whole effluent toxicity in effluents. If the permitting authority can demonstrate that control of specific chemicals is sufficient to control toxicity to the point of achieving compliance with the water quality criteria, then chemical-specific permit limits alone will be sufficient to comply with the regulation.

40 *CFR* 122.44(d)(1)(vi)

> Where a State has not established a water quality criterion for a specific chemical pollutant that is present in an effluent at a concentration that causes, has the reasonable potential to cause, or contributes to an excursion above a narrative criterion within an applicable State water quality standard, the permitting authority must establish effluent limits using one or more of the following [three] options: ....

Under this regulation, permitting authorities need to investigate for the existence of specific chemicals in effluents for which the State has not adopted numeric criteria, but which may be contributing to aquatic toxicity or impairment of human health. Narrative criteria apply when numeric criteria do not protect all the designated or existing uses. For example, the narrative criteria need to be used to protect human health if a State has only adopted a numeric criteria for protecting aquatic life. Conversely, the narrative criteria need to be used to protect aquatic life if a State has only adopted a numeric criteria for protecting human health. Once the permitting authority determines that one or more specific chemicals in an effluent must be controlled, the authorities can use EPA's national criteria, develop their own criteria, or control the pollutant through use of an indicator pollutant, as provided in subparagraph (d)(1)(vi). In any case, the permitting authority will need to characterize the effluent in a manner consistent with the selected approach for controlling the pollutant.

3.1.2 Background for Toxic Effects Assessments on Aquatic Life and Human Health

Aquatic toxicity effects can be characterized by conducting a general assessment of the effluent, or by measuring effluent toxicity or concentrations of individual chemicals and comparing these measurements to the expected exposure concentrations in the receiving water. The "receiving water concentration" (RWC) is the measured or projected exposure concentration of a toxicant or the parameter toxicity (when dealing with the whole effluent toxicity) in the receiving water after mixing. The RWC is calculated at the edge of a mixing zone if such a zone is allowed by a State's water quality standards.

As with aquatic life protection, there are two possible approaches to characterizing effluents for human health effects: chemical-by-chemical and whole effluent. However, only the chemical-by-chemical approach currently is practical for assessing and controlling human health impacts. Appendix C discusses developing procedures for assessing human health impacts from whole effluents.

A fundamental principle in the development of water quality-based controls is that the RWC must be less than the criteria that comprise or characterize the water quality standards. With individual toxicants (or the parameter toxicity), the potential for toxicity in the receiving water is minimized where the RWC is less than the criterion continuous concentration (CCC), the criterion maximum concentration (CMC), and the reference ambient concentration (RAC). Toxicity becomes maximized where the RWC exceeds these criteria. **Therefore, to prevent impacts to aquatic life or human health, the RWC of the parameter effluent toxicity or an individual toxicant (based on allowable dilution for the criterion) must be less than the most limiting of the applicable criterion, as indicated below.** (The RAC as used throughout this chapter incorporates EPA human health criteria and State standards as well.)

RWC < CCC (chronic aquatic life)
RWC < CMC (acute aquatic life)
RWC < RAC (human health)

The water quality analyst will use the same basic components in the above-described relationship (i.e., critical receiving water flows, ambient criteria values, measures of effluent quality) for both effluent characterization and wasteload allocation (WLA) development, albeit from different perspectives. In the case of effluent characterization, the objective is to project receiving water concentrations based upon existing effluent quality to determine whether or not an excursion above ambient criteria occurs, or has the reasonable potential to occur. In developing WLAs, on the other hand, the objective is to fix the RWC at the desired criteria level and determine an allowable effluent loading that will not cause excursions above the criteria.

Recommendations for projecting the RWC are described within this chapter. Chapter 4, Exposure Assessment and Wasteload Allocation, provides recommendations for determining allowable effluent loadings to achieve established ambient criteria and for calculating WLAs for establishing permit limits. The procedures described within Chapter 4 can also be used to calculate the dilution for analyses within Chapter 3. Chapter 5, Permit Requirements, describes the actual calculation of permit limits after effluent characterization and loadings, as well as WLAs, are complete.

3.1.3 General Considerations in Effluent Characterization

There are two possible ways to characterize an effluent to determine the need for effluent limits for the protection of aquatic life and human health. First, an assessment may be made without generating effluent data; second, an assessment may be conducted after effluent data have been generated. Regulatory authorities must determine whether a discharge causes, has the "reasonable potential" to cause, or contributes to an excursion above an applicable narrative or numeric water quality criterion. An analysis of "reasonable potential" determines an effluent's capability to cause such excursions.

In determining the need for a permit limit for whole effluent toxicity or for an individual toxicant, the regulatory authority is required to consider, at a minimum, existing controls on point and nonpoint sources of pollution, the variability of the pollutant or pollutant parameter in the effluent, the sensitivity of the involved species to toxicity testing (for whole effluent), and, where appropriate, the dilution of the effluent in the receiving water (40 *CFR* 122.44(d)(ii)).

The regulatory authority is also required by NPDES regulations to consider whether technology-based limits are sufficient to maintain State water quality standards. There are two possibilities that will need to be assessed. First, if the limits based on appropriate treatment technology have already been specified in a previous permit, and if the facility is operating at the required level, then historical effluent and receiving water information can be used. Second, if the facility has yet to achieve the required technology performance (best available technology or best conventional technology), the regulatory authority will need to assess the technology-based limit for reasonable potential for causing or contributing to an excursion above the water quality standard.

In addition, the regulatory authority should consider all other available data and information pertaining to the discharger to assist in making an informed judgment. Where both effluent testing data and important other factors exist, the regulatory authority will need to exercise discretion in the determination of the need for a limit. **The authority should employ the principle of "independent application" of the data and information that characterizes the effluent.** In other words, effluent data alone, showing toxicity at the RWC, may be adequate to demonstrate the need for a limit for toxicity or for individual toxicants. Likewise, other factors may form an adequate basis for determining that limits are necessary. For example, where available dilution is low and monitoring information shows that toxic pollutants are frequently discharged at concentrations that have caused toxicity when discharged from similar facilities, the permitting authority may reason that a whole effluent toxicity limit is necessary even without whole effluent toxicity data from the specific facility. In all cases, the decision must be based upon consideration of factors cited in 40 *CFR* 122.44(d)(1)(ii). The regulatory authority will need to prioritize, on a case-by-case basis, the importance of all data and information used in making a determination. To assist in case-by-case determinations, recommended guidelines for characterizing an effluent for the need for a permit limit for whole effluent toxicity or individual toxicants are discussed below and summarized in Boxes 3-1 through 3-3.

Box 3-1. Determining "Reasonable Potential" for Excursions Above Ambient Criteria Using Factors Other than Facility-specific Effluent Monitoring Data

When determining the "reasonable potential" of a discharge to cause an excursion above a State water quality standard, the regulatory authority must consider all the factors listed in 40 *CFR* 122.44(d)(1)(ii). Examples of the types of information relating to these factors are listed below.

<u>Existing controls on point and nonpoint sources of pollution</u>

- Industry type: Primary, secondary, raw materials used, products produced, best management practices, control equipment, treatment efficiency, etc.
- Publicly owned treatment work type: Pretreatment, industrial loadings, number of taps, unit processes, treatment efficiencies, chlorination/ammonia problems, etc.

<u>Variability of the pollutant or pollutant parameter in the effluent</u>

- Compliance history
- Existing chemical data from discharge monitoring reports and applications.

<u>Sensitivity of the species to toxicity testing</u>

- Adopted State water quality criteria, or EPA criteria
- Any available in-stream survey data **applied under independent application of water quality standards**
- Receiving water type and designated/existing uses

<u>Dilution of the effluent in the receiving water</u>

- Dilution calculations

3.2 DETERMINING THE NEED FOR PERMIT LIMITS WITHOUT EFFLUENT MONITORING DATA FOR A SPECIFIC FACILITY

If the regulatory authority so chooses, or if the circumstances dictate, the authority may decide to develop and impose a permit limit for whole effluent toxicity or for individual toxicants without facility-specific effluent monitoring data, or prior to the generation of effluent data. Water quality-based permit limits can be set for a single toxicant or for whole effluent toxicity based on the available dilution and the water quality criterion or the State standard in the absence of facility specific effluent monitoring data. However, in doing so, the regulatory authority must satisfy all the requirements of 40 *CFR* 122.44(d)(1)(ii).

When determining whether or not a discharge causes, has the reasonable potential to cause, or contributes to an excursion of a numeric or narrative water quality criterion for individual toxicants or for toxicity, the regulatory authority can use a variety of factors and information where facility-specific effluent monitoring data are unavailable. These factors also should be considered with available effluent monitoring data. Some of these factors are the following:

- **Dilution**—Toxic impact is directly related to available dilution for the effluent. Dilution is related to the receiving stream flow and the size of the discharge. The lower the available dilution, the higher the potential for toxic effect. If an effluent's concentration at the edge of a mixing zone in a receiving water is expected to reach 1 percent or higher during critical or worst-case design periods, then such an effluent may require a toxicity limit (see discussion in Section 3.3.3). Assessment of the amount of stream dilution available should be made at the conditions required by the water quality standards or, if not specified in the standards, at the harmonic mean flow and the 7Q10 flow. Figure 3-3 (Pg. 57) shows that, whereas a majority of NPDES permittees nationwide discharge to areas during annual mean flow ranging in dilution from 100 to 1,000, the majority of dischargers fall into the 1 to 10 dilution range during low-flow conditions.

- **Type of industry**—Although dischargers should be individually characterized because toxicity problems are site-specific, the primary industrial categories should be of principal toxicity concern. EPA's treatment technology data base generally suggests that secondary industrial categories may have less potential for toxicity than primary industries. However, based on experience, it is virtually impossible to generalize the toxicity of effluents with any certainty. If two plants produce the same type of product, one effluent may be toxic while the other may not be toxic due to the type and efficiency of the treatment applied, general materials handling practices, and the functional target of the compound(s) being produced.

- **Type of POTW**—POTWs with loadings from indirect dischargers (particularly primary industries) may be candidates for toxicity limits. However, absence of industrial input does not guarantee an absence of POTW discharge toxicity problems. For example, commercial pesticide applicators often discharge to POTWs, resulting in pesticide concentrations in the POTW's effluent. Household disposal of pesticides, detergents, or other toxics may have a similar effect. The types of industrial users, their product lines, their raw materials, their potential and actual discharges, and their control equipment should be evaluated. POTWs should also be characterized for the possibility of chlorine and ammonia problems.

- **Existing data on toxic pollutants**—Discharge monitoring reports (DMRs) and data from NPDES permit application forms 2C and 2A may provide some indication of the presence of toxicants. The presence or absence of the 126 "priority pollutants" may or may not be an indication of the presence or absence of toxicity. There are thousands of "nonpriority" toxicants that may cause effluent toxicity. Also, combinations of several toxicants can produce ambient toxicity where the individual toxicants would not. EPA regulations at 40 *CFR* 122.21(j) require POTWs with design flows equal to or greater than 1 MGD and POTWs with approved pretreatment programs, or POTWs required to develop a pretreatment program, to submit the results of whole effluent toxicity tests with their permit applications. These regulations also provide discretion to the permitting authority to request such data from other POTWs at the time of permit application.

- **History of compliance problems and toxic impact**—Regulatory authorities may consider particular dischargers that have had difficulty complying with limits on toxicants or that have a history of known toxicity impacts as probable priority candidates for effluent toxicity limits.

- **Type of receiving water and designated use**—Regulatory authorities may compile data on water quality. Examples of available data include fish advisories or bans, reports of fish kills, State lists of priority waterbodies, and State lists of waters that are not meeting water quality standards. Regulatory authorities should use this information as a means of identifying point sources that discharge to impaired waterbodies and that thus may be contributing to this impairment. One source of this information is the lists of waters generated by states to comply with Section 304(l) regulations at 40 *CFR* 130.10(d)(6); 50 *FR* 23897-98, June 2, 1989:

    1) Waters where fishing or shellfish bans and/or advisories are currently in effect or are anticipated;

    2) Waters where there have been repeated fish kills or where abnormalities (cancers, lesions, tumors, etc.) have been observed in fish or other aquatic life during the last ten years;

    3) Waters where there are restrictions on water sports or recreational contact;

    4) Waters identified by the state in its most recent state section 305(b) report as either "partially achieving" or "not achieving" designated uses;

5) Waters identified by the states under section 303(d) of the Clean Water Act as waters needing water quality-based controls;

6) Waters identified by the state as priority water bodies;

7) Waters where ambient data indicate potential or actual excursions of water quality criteria due to toxic pollutants from an industry classified as a primary industry in Appendix A of 40 CFR Part 122;

8) Waters for which effluent toxicity test results indicate possible or actual excursions of state water quality standards, including narrative "free from" water quality criteria or EPA water quality criteria where state criteria are not available;

9) Waters with primary industrial major dischargers where dilution analyses indicate exceedances of state narrative or numeric water quality criteria (or EPA water quality criteria where state standards are not available) fortoxic pollutants, ammonia, or chlorine;

10) Waters with POTW dischargers requiring local pretreatment programs where dilution analyses indicate exceedances of state water quality criteria (or EPA water quality criteria where state water quality criteria are not available) for toxic pollutants, ammonia, or chlorine;

11) Waters with facilities not included in the previous two categories such as major POTWs, and industrial minor dischargers where dilution analyses indicate exceedances of numeric or narrative state water quality criteria (or EPA water quality criteria where state water quality criteria are not available) for toxic pollutants, ammonia, or chlorine;

12) Water classified for uses that will not support the "fishable/swimmable" goals of the Clean Water Act;

13) Waters where ambient toxicity or adverse water quality conditions have been reported by local, state, EPA or other Federal Agencies, the private sector, public interest groups, or universities;

14) Waters identified by the state as impaired in its most recent Clean Lake Assessments conducted under 314 of the Clean Water Act; and

15) Surface waters impaired by pollutants from hazardous waste sites on the National Priority List prepared under section 105(8)(A) of CERCLA.

16) Waters judged to be impaired as a result of a bioassessment/biosurvey.

The presence of a combination of these factors, such as low available dilution, high-quality receiving water, poor compliance record, and clustered industrial and municipal discharges, could constitute a high priority for effluent limits.

Regardless, the regulatory authority, if it chooses to impose an effluent limit after conducting an effluent assessment without facility-specific monitoring data, will need to provide adequate justification for the limit in its permit development rationale or in its permit fact sheet. A clear and logical rationale for the need for the limit covering all of the regulatory points will be necessary to defend the limit should it be challenged. In justification of a limit, **EPA recommends that the more information the authority can acquire to support the limit, the better a position the authority will be in to defend the limit if necessary.** In such a case, the regulatory authority may well benefit from the collection of effluent monitoring data prior to establishing the limit.

If the regulatory authority, after evaluating all available information on the effluent, in the absence of effluent monitoring data, is not able to decide whether the discharge causes, has the reasonable potential to cause, or contributes to, an excursion above a numeric or narrative criterion for whole effluent toxicity or for individual toxicants, the authority should require whole effluent toxicity or chemical-specific testing to gather further evidence. In such a case, the regulatory authority can require the monitoring prior to permit issuance, if sufficient time exists, or it may require the testing as a condition of the issued/reissued permit.

Under these circumstances, the regulatory authority may find it protective of water quality to include a permit reopener for the imposition of an effluent limit should the effluent testing establish that the discharge causes, has the reasonable potential to cause, or contributes to excursion above a water quality criteria. A discussion of these options is provided later in this chapter.

3.3 DETERMINING THE NEED FOR PERMIT LIMITS WITH EFFLUENT MONITORING DATA

3.3.1 General Considerations

When characterizing an effluent for the need for a whole effluent toxicity limit, and/or an individual toxicant limit, the regulatory authority should use any available effluent monitoring data, together with any information like that discussed under Section 3.2 above, as the basis for a decision. The regulatory authority may already have effluent toxicity data available from previous monitoring, or it may decide to require the permittee to generate effluent monitoring data prior to permit issuance or as a condition of the issued permit. EPA regulations at 40 *CFR* 122.21(j) require POTWs with design flows equal to or greater than 1 MGD and POTWs with approved pretreatment programs, or POTWs required to develop a pretreatment program, to submit the results of whole effluent toxicity tests with their permit applications. These regulations also provide discretion to the permitting authority to request such data from additional POTWs at the time of permit application.

In the instance where the permittee is required to generate data in advance, data collection should begin 12 to 18 months in advance of permit development to allow adequate time for conducting toxicity tests and chemical analyses. The type of data, including toxicity testing data, should be specified by the regulatory authority at the outset so that decisions on permit actions will not be delayed. **EPA recommends monitoring data be generated on effluent toxicity prior to permit limit development for the following reasons: (1) the presence or absence of effluent toxicity can be more clearly established or refuted and (2) where toxicity is shown, effluent variability can be more clearly defined.** Several basic factors that should be considered in generating effluent monitoring data are discussed below.

3.3.2 Addressing Uncertainty in Effluent Characterization by Generating Effluent Monitoring Data

All toxic effects testing and exposure assessment parameters, for both effluent toxicity and individual chemicals, have some degree of uncertainty associated with them. The more limited the amount of test data available, the larger the uncertainty. The least amount of uncertainty of an effluent's impact on the receiving water exists where (1) a complete data base is available on the effects of acute and chronic toxicity on many indigenous species, (2) there is a clear understanding of ecosystem species composition and functional processes, and (3) actual measured exposure concentrations are available for all chemicals during seasonal changes and dilution situations. The uncertainty associated with such an ideal situation would be minimal. However, generation of these data can be very resource intensive.

An example of uncertainty that results from limited monitoring data is if a regulatory authority has only one piece of effluent data (e.g., an LC_{50} of 50 percent) for a facility. Effluent variability in such a case, given the range of effluent toxicity variability seen in other effluents, may range between 20 percent and 100 percent (see Appendix A). It is impossible to determine from one piece of monitoring data where in this range the effluent variability really falls. More monitoring data would need to be generated to determine the actual variability of this effluent and reduce this source of uncertainty.

To better characterize the effects of effluent variability and reduce uncertainty in the process of deciding whether to require an effluent limit, EPA has developed the statistical approach described below and in Box 3-2. This approach combines knowledge of effluent variability as estimated by a coefficient of variation with the uncertainty due to a limited number of data to project an estimated maximum concentration for the effluent. The estimated maximum concentration is calculated as the upper bound of the expected lognormal distribution of effluent concentrations at a high confidence level. The projected effluent concentration after consideration of dilution can then be compared to an appropriate water quality criterion to determine the potential for exceeding that criterion and the need for an effluent limit.

The statistical approach has two parts. The first is a characterization of the highest measured effluent concentration based on the desired confidence level. The relationship that describes this is the following:

$$p_n = (1 - \text{confidence level})^{1/n}$$

where p_n is the percentile represented by the highest concentration in the data and n is the number of samples. The following are some examples of this relationship at a 99 percent confidence level:

- The largest value of 5 samples is greater than the 40 percentile
- The largest value of 10 samples is greater than the 63 percentile
- The largest value of 20 samples is greater than the 79 percentile
- The largest value of 100 samples is greater than the 96 percentile.

The second part of the statistical approach is a relationship between the percentile described above and the selected upper bound of the lognormal effluent distribution. EPA's effluent data base suggests that the lognormal distribution well characterizes effluent concentrations (see Appendix E). For example, if five samples were collected (which represents a 40th percentile), the coefficient of variation is 0.6, and the desired upper bound of the effluent distribution is the 99th percentile, then the two percentiles can be related using the coefficient of variation (CV) as shown below:

$$\frac{C_{99}}{C_{40}} = \frac{\exp(2.326\sigma - 0.5\sigma^2)}{\exp(-0.258\sigma - 0.5\sigma^2)} = 4.2$$

where $\sigma^2 = \ln(CV^2+1)$ and 2.326 and -0.258 are the normal distribution values for the 99th and 40th percentiles, respectively. The use of the 99th percentile is for illustrative purposes here. Although it does represent a measure of the upper bound of an effluent distribution, other percentiles could be selected by a regulatory agency. The relationship shown above can be calculated for other percentiles and CVs by replacing the values in the equation.

Tables 3-1 and 3-2 show the combined effects of both parts for a 99-percent confidence level and upper bounds of the 99th and 95th percentiles, respectively. The factors shown in the tables are multiplied by the highest concentration in an effluent sample to estimate the maximum expected concentration.

This procedure can be used for both single and multiple discharges to the same receiving waterbody. This is accomplished for multiple dischargers by summing the projected RWCs for the pollutant or pollutant parameter of concern from each individual discharger, and comparing it to the water quality standard. This involves an assumption of conservative additivity of the pollutant after discharge, which may not accurately reflect the true behavior of the toxicant. To overcome this, and to further refine the proportional contribution of each discharger and the resultant limits, the permitting authority should supplement this evaluation with multiple source WLA modeling and/or ambient water concentration monitoring.

Box 3-2. Determining "Reasonable Potential" for Excursions Above Ambient Criteria Using Effluent Data Only

EPA recommends finding that a permittee has "reasonable potential" to exceed a receiving water quality standard if it cannot be demonstrated with a high confidence level that the upper bound of the lognormal distribution of effluent concentrations is below the receiving water criteria at specified low-flow conditions.

Step 1 Determine the number of total observations ("n") for a particular set of effluent data (concentrations or toxic units [TUs]), and determine the highest value from that data set.

Step 2 Determine the coefficient of variation for the data set. For a data set where $n<10$, the coefficient of variation (CV) is estimated to equal 0.6, or the CV is calculated from data obtained from a discharger. For a data set where $n>10$, the CV is calculated as standard deviation/mean (see Figure 3-1). For less than 10 items of data, the uncertainty in the CV is too large to calculate a standard deviation or mean with sufficient confidence.

Step 3 Determine the appropriate ratio from Table 3-1 or 3-2.

Step 4 Multiply the highest value from a data set by the value from Table 3-1 or 3-2. Use this value with the appropriate dilution to project a maximum receiving water concentration (RWC).

Step 5 Compare the projected maximum RWC to the applicable standard (criteria maximum concentration, criteria continuous concentration [CCC], or reference ambient concentration). EPA recommends that permitting authorities find reasonable potential when the projected RWC is greater than an ambient criterion.

Example

Consider the following results of toxicity measurements of an effluent that is being characterized: 5 TU_c, 2 TU_c, 9 TU_c, and 6 TU_c. Assume that the effluent is diluted to 2 percent at the edge of the mixing zone. Further assume that the CV is 0.6, the upper bound of the effluent distribution is the 99th percentile, and the confidence level is 99 percent.

Step 1 There are four samples, and the maximum value of the sample results is 9 TU_c.

Step 2 The value of the CV is 0.6.

Step 3 The value of the ratio for four pieces of data and a CV of 0.6 is 4.7.

Step 4 The value that exceeds the 99th percentile of the distribution (ratio times x_{max}) after dilution is calculated as:

$$[9\ TU_c \times 4.7 \times 0.02] = 0.85\ TU_c.$$

Step 5 0.85 TU_c is less than the ambient criteria concentration of 1.0 TU_c. There is no reasonable potential for this effluent to cause an excursion above the CCC.

3.3.3 *Effluent Characterization for Whole Effluent Toxicity*

Once an effluent has been selected for whole effluent toxicity characterization after consideration of the factors discussed above, the regulatory authority should require toxicity testing in accordance with appropriate site-specific considerations and the recommendations discussed below. In the past 5 years, significant additional experience has been gained in generating effluent toxicity data upon which to make decisions as to whether or not an effluent will cause toxic effects in the receiving water in both freshwater and marine environments.

General Considerations and Assumptions

EPA has revised its initial effluent toxicity data generation recommendations based on three observations made over the last 5 years:

1) Only rarely have effluents discharged by NPDES permittees been observed to have LC_{50}s less than 1.0 percent or no observed effect concentrations (NOECs) less than 0.1 percent. However, there is always a chance that an effluent could be toxic at such low effluent concentrations.

Table 3-1. Reasonable Potential Multiplying Factors: 99% Confidence Level and 99% Probability Basis

Number of	Coefficient of Variation																			
Samples	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
1	1.6	2.5	3.9	6.0	9.0	13.2	18.9	26.5	36.2	48.3	63.3	81.4	102.8	128.0	157.1	190.3	227.8	269.9	316.7	368.3
2	1.4	2.0	2.9	4.0	5.5	7.4	9.8	12.7	16.1	20.2	24.9	30.3	36.3	43.0	50.4	58.4	67.2	76.6	86.7	97.5
3	1.4	1.9	2.5	3.3	4.4	5.6	7.2	8.9	11.0	13.4	16.0	19.0	22.2	25.7	29.4	33.5	37.7	42.3	47.0	52.0
4	1.3	1.7	2.3	2.9	3.8	4.7	5.9	7.2	8.7	10.3	12.2	14.2	16.3	18.6	21.0	23.6	26.3	29.1	32.1	35.1
5	1.3	1.7	2.1	2.7	3.4	4.2	5.1	6.2	7.3	8.6	10.0	11.5	13.1	14.8	16.6	18.4	20.4	22.4	24.5	26.6
6	1.3	1.6	2.0	2.5	3.1	3.8	4.6	5.5	6.4	7.5	8.6	9.8	11.1	12.4	13.8	15.3	16.8	18.3	19.9	21.5
7	1.3	1.6	2.0	2.4	2.9	3.6	4.2	5.0	5.8	6.7	7.7	8.7	9.7	10.8	12.0	13.1	14.4	15.6	16.9	18.2
8	1.2	1.5	1.9	2.3	2.8	3.3	3.9	4.6	5.3	6.1	6.9	7.8	8.7	9.6	10.6	11.6	12.6	13.6	14.7	15.8
9	1.2	1.5	1.8	2.2	2.7	3.2	3.7	4.3	5.0	5.7	6.4	7.1	7.9	8.7	9.6	10.4	11.3	12.2	13.1	14.0
10	1.2	1.5	1.8	2.2	2.6	3.0	3.5	4.1	4.7	5.3	5.9	6.6	7.3	8.0	8.8	9.5	10.3	11.0	11.8	12.6
11	1.2	1.5	1.8	2.1	2.5	2.9	3.4	3.9	4.4	5.0	5.6	6.2	6.8	7.4	8.1	8.8	9.4	10.1	10.8	11.5
12	1.2	1.4	1.7	2.0	2.4	2.8	3.2	3.7	4.2	4.7	5.2	5.8	6.4	7.0	7.5	8.1	8.8	9.4	10.0	10.6
13	1.2	1.4	1.7	2.0	2.3	2.7	3.1	3.6	4.0	4.5	5.0	5.5	6.0	6.5	7.1	7.6	8.2	8.7	9.3	9.9
14	1.2	1.4	1.7	2.0	2.3	2.6	3.0	3.4	3.9	4.3	4.8	5.2	5.7	6.2	6.7	7.2	7.7	8.2	8.7	9.2
15	1.2	1.4	1.6	1.9	2.2	2.6	2.9	3.3	3.7	4.1	4.6	5.0	5.4	5.9	6.4	6.8	7.3	7.7	8.2	8.7
16	1.2	1.4	1.6	1.9	2.2	2.5	2.9	3.2	3.6	4.0	4.4	4.8	5.2	5.6	6.1	6.5	6.9	7.3	7.8	8.2
17	1.2	1.4	1.6	1.9	2.1	2.5	2.8	3.1	3.5	3.8	4.2	4.6	5.0	5.4	5.8	6.2	6.6	7.0	7.4	7.8
18	1.2	1.4	1.6	1.8	2.1	2.4	2.7	3.0	3.4	3.7	4.1	4.4	4.8	5.2	5.6	5.9	6.3	6.7	7.0	7.4
19	1.2	1.4	1.6	1.8	2.1	2.4	2.7	3.0	3.3	3.6	4.0	4.3	4.6	5.0	5.3	5.7	6.0	6.4	6.7	7.1
20	1.2	1.3	1.6	1.8	2.0	2.3	2.6	2.9	3.2	3.5	3.8	4.2	4.5	4.8	5.2	5.5	5.8	6.1	6.5	6.8

Table 3-2. Reasonable Potential Multiplying Factors: 95% Confidence Level and 95% Probability Basis

Number of	Coefficient of Variation																			
Samples	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
1	1.4	1.9	2.6	3.6	4.7	6.2	8.0	10.1	12.6	15.5	18.7	22.3	26.4	30.8	35.6	40.7	46.2	52.1	58.4	64.9
2	1.3	1.6	2.0	2.5	3.1	3.8	4.6	5.4	6.4	7.4	8.5	9.7	10.9	12.2	13.6	15.0	16.4	17.9	19.5	21.1
3	1.2	1.5	1.8	2.1	2.5	3.0	3.5	4.0	4.6	5.2	5.8	6.5	7.2	7.9	8.6	9.3	10.0	10.8	11.5	12.3
4	1.2	1.4	1.7	1.9	2.2	2.6	2.9	3.3	3.7	4.2	4.6	5.0	5.5	6.0	6.4	6.9	7.4	7.8	8.3	8.8
5	1.2	1.4	1.6	1.8	2.1	2.3	2.6	2.9	3.2	3.6	3.9	4.2	4.5	4.9	5.2	5.6	5.9	6.2	6.6	6.9
6	1.1	1.3	1.5	1.7	1.9	2.1	2.4	2.6	2.9	3.1	3.4	3.7	3.9	4.2	4.5	4.7	5.0	5.2	5.5	5.7
7	1.1	1.3	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.1	3.3	3.5	3.7	3.9	4.1	4.3	4.5	4.7	4.9
8	1.1	1.3	1.4	1.6	1.7	1.9	2.1	2.3	2.4	2.6	2.8	3.0	3.2	3.3	3.5	3.7	3.9	4.0	4.2	4.3
9	1.1	1.2	1.4	1.5	1.7	1.8	2.0	2.1	2.3	2.4	2.6	2.8	2.9	3.1	3.2	3.4	3.5	3.6	3.8	3.9
10	1.1	1.2	1.3	1.5	1.6	1.7	1.9	2.0	2.2	2.3	2.4	2.6	2.7	2.8	3.0	3.1	3.2	3.3	3.4	3.6
11	1.1	1.2	1.3	1.4	1.6	1.7	1.8	1.9	2.1	2.2	2.3	2.4	2.5	2.7	2.8	2.9	3.0	3.1	3.2	3.3
12	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.0
13	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.5	2.6	2.7	2.8	2.9
14	1.1	1.2	1.3	1.4	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.3	2.4	2.5	2.6	2.6	2.7
15	1.1	1.2	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.8	1.9	2.0	2.1	2.2	2.2	2.3	2.4	2.4	2.5	2.5
16	1.1	1.1	1.2	1.3	1.4	1.5	1.6	1.6	1.7	1.8	1.9	1.9	2.0	2.1	2.1	2.2	2.3	2.3	2.4	2.4
17	1.1	1.1	1.2	1.3	1.4	1.4	1.5	1.6	1.7	1.7	1.8	1.9	1.9	2.0	2.0	2.1	2.2	2.2	2.3	2.3
18	1.1	1.1	1.2	1.3	1.3	1.4	1.5	1.6	1.6	1.7	1.7	1.8	1.9	1.9	2.0	2.0	2.1	2.1	2.2	2.2
19	1.1	1.1	1.2	1.3	1.3	1.4	1.5	1.5	1.6	1.6	1.7	1.8	1.8	1.9	1.9	2.0	2.0	2.0	2.1	2.1
20	1.1	1.1	1.2	1.2	1.3	1.4	1.4	1.5	1.5	1.6	1.7	1.7	1.8	1.8	1.8	1.9	1.9	2.0	2.0	2.0

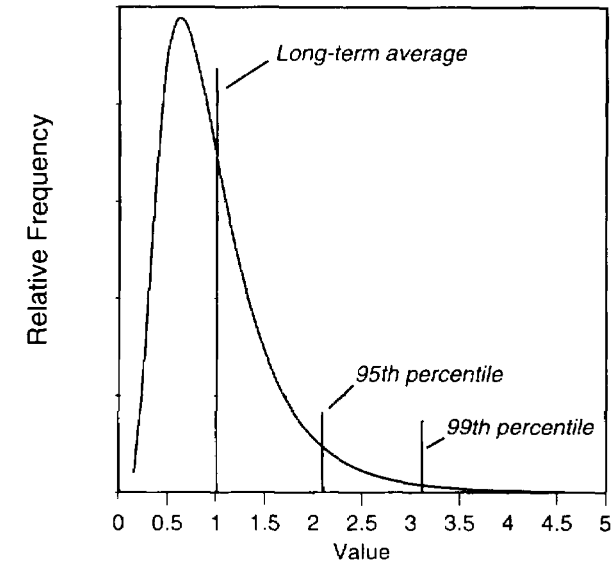


Figure 3-1a. Frequency Distribution of Values for a Lognormal Distribution with a Mean of 1.0 and a Coefficient of Variation of 0.6

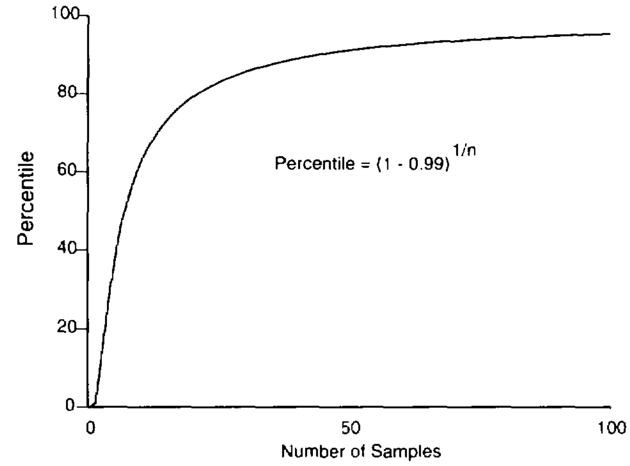


Figure 3-1c. Relationship Between the Largest Value of n Samples and the Percentile It Exceeds with 99 Percent Confidence

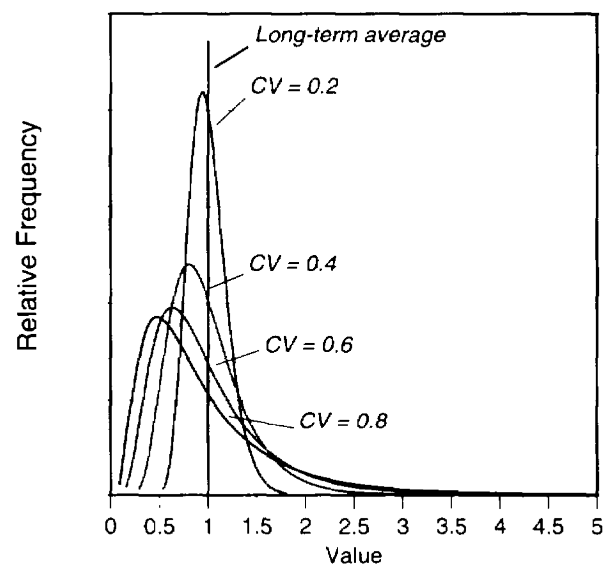


Figure 3-1b. Comparison of Relative Frequencies of Lognormal Distributions with a Mean of 1.0 for Different Coefficients of Variation

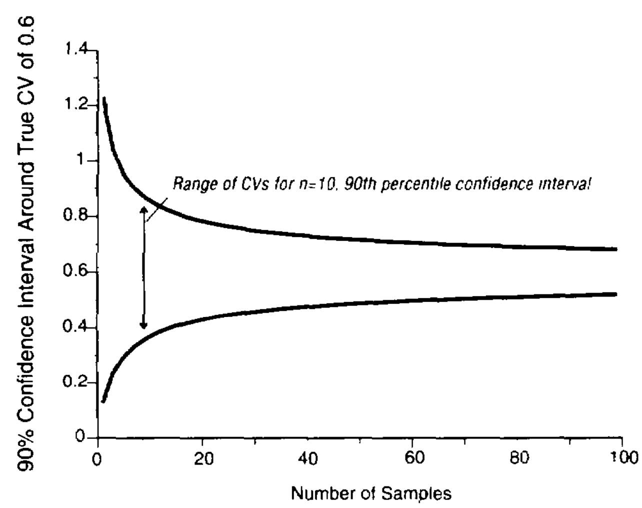
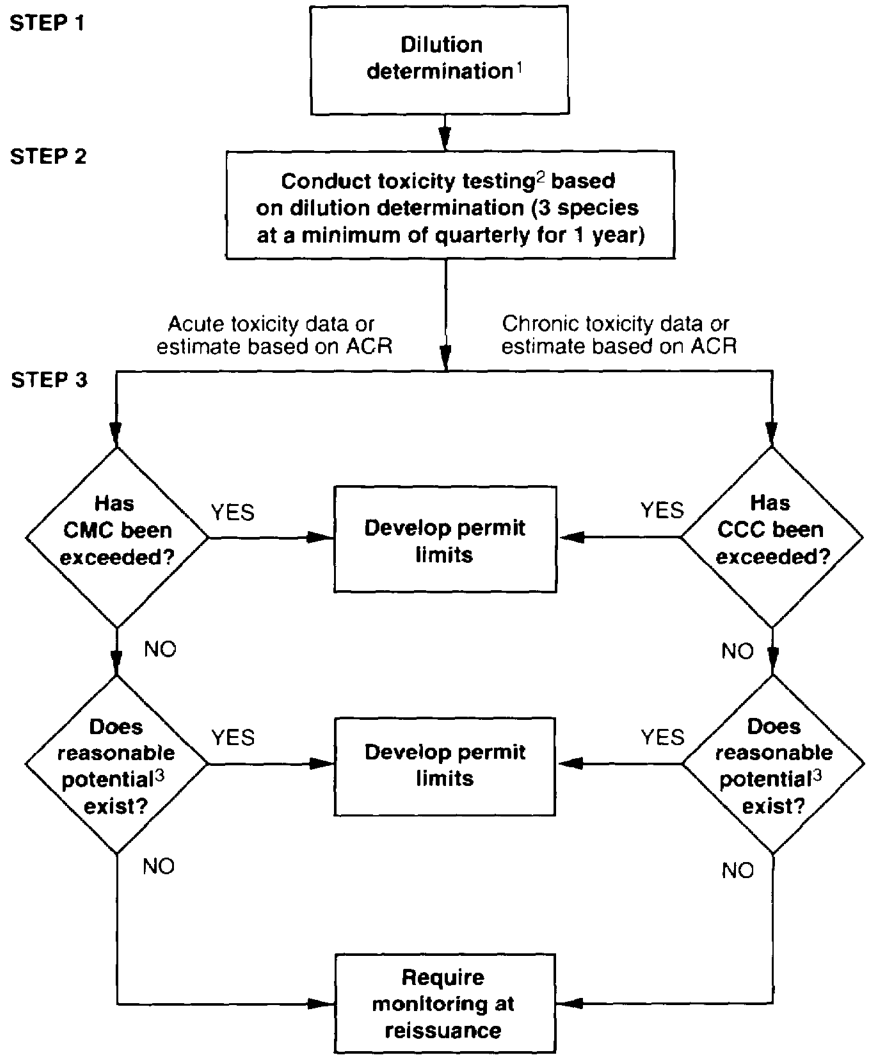


Figure 3-1d. Example of 90 Percent Confidence Intervals Around Coefficient of Variation Estimates for Numbers of Samples

2) With the exception of a small number of "outliers" for which confirmation is not possible, acute-to-chronic ratios (ACRs) above 20 for effluents discharged by NPDES permittees have not been observed by EPA. The majority of observed ACRs are very seldom above 10. However, higher ACRs may be found for selected facilities.

3) The use of the three commonly used freshwater species and of three of the five commonly used marine organisms has generally been sufficient to measure any effluent's toxicity for the purposes of projecting effluent toxicity impact and making regulatory decisions.

Figure 3-2 is a flow chart of EPA's recommendations for data generation for three different dilution scenarios. It is divided into three basic steps: determining initial dilution, developing toxicity testing procedures, and developing decision criteria for permit limit. There are certain basic assumptions built into this flow chart. The basic principle used in making decisions is to compare available dilution to known or projected toxic effect concentrations in order to place an effluent into one of three categories:



Notes:

[1]Dilution determinations should be performed for critical flows and any applicable mixing zones.

[2]Toxicity testing recommendations

a. Dilution > 1000:1: acute testing, check CMC only.

b. 100:1 < Dilution < 1000:1: acute or chronic testing, check CMC and CCC with data or ACR.

c. Dilution < 100:1: conduct chronic testing, check CCC with data and CMC using acute data or ACR.

[3]Reasonable potential: Use procedures in Box 3-3.

Figure 3-2. Effluent Characterization for Whole Effluent Toxicity

1) The effluent causes or contributes to an excursion of a numeric or narrative water quality criterion and the permit requires a limit on toxicity.

2) The effluent has a reasonable potential of causing or contributing to an excursion of a numeric or narrative water quality criterion and a limit is required.

3) The effluent has a very low probability of causing or contributing to an excursion of a water quality standard and no limit is required.

This categorization is accomplished by using dilution estimates in the first step and the results of the toxicity tests in the next steps. In addition, all these impact estimates assume discharge at critical conditions and imposition of any applicable mixing zone requirements. Therefore, a conservative assumption is used to determine whether or not an impact is projected to occur. Estimates of possible toxic impact are made assuming that the effluent is most toxic to the most sensitive species or lifestage at the time of lowest available dilution.

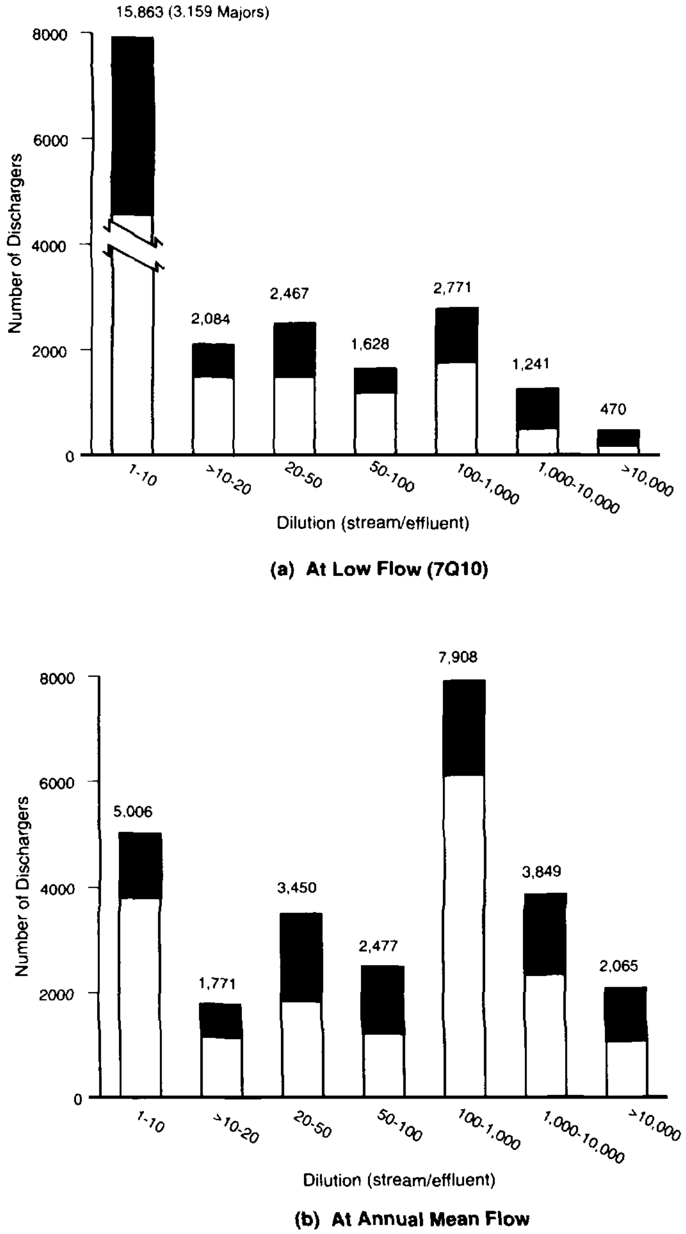


Figure 3-3. National Distribution of NPDES Dilution Conditions at 7Q10 and at Annual Mean Flow

The changes to the EPA's data generation recommendations eliminate the application of multiple sets of safety margins that was proposed in the 1985 version of this document. Rather, general observations on effluent toxicity described above now allow regulatory authorities to tighten the bounds of the initial dilution categorization, eliminate the species sensitivity uncertainty factor and target LC_{50}s of 1 percent and NOECs of 0.1 percent as the most extreme toxicity measurements that can normally be expected for the vast majority of effluents discharged by NPDES permittees for acute and chronic toxicity, respectively. The observation of toxicity was based on multiple dilution tests. The same observation may not hold for toxicity measured with single dilution tests (pass/fail). As reflected in Chapter 1, single dilution toxicity tests are much more variable than multiple dilution tests. **Therefore, the use of single concentration toxicity tests is strongly discouraged for this data generation process.**

Since the new data generation requirements are much less expensive than the previous requirements, tiered testing (less expensive, single-concentration, initial screening followed by increasingly expensive definitive data generation, using multiconcentration tests, as described in the September 1985 version of the technical support document) is unnecessary. However, **elimination of the requirement to conduct toxicity testing on the basis of projections using dilution alone is not recommended.** Although EPA's data review suggests that an LC_{50} of 1 percent and an NOEC of 0.1 percent are the lower bounds on effluent toxicity, there may be other effluents that are presently unmeasured that are more toxic. Testing data are always desirable for fully characterizing discharges of concern.

Steps in Whole Effluent Characterization Process

The following is a detailed description of the major steps presented in Figure 3-2 and the rationale behind each.

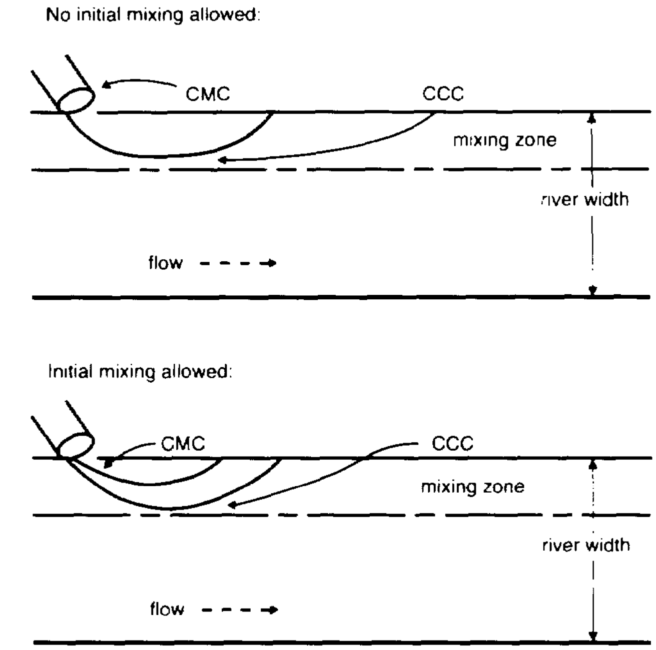
Step 1: Dilution Determination

The initial step is to determine the dilution of the effluent at the edge of the mixing zone, assuming the State allows mixing zones. Figure 3-4 shows a schematic representation of typical mixing zone requirements for both acute and chronic toxicity. Calculating the dilution at the edges of mixing zones for site-specific situations can be complicated. Modeling can be employed using either steady-state or dynamic approaches to calculate the dilution (see Chapter 4). However, for complex situations, such as marine and estuarine waters or lakes, dye studies (or other techniques used to assess mixing zones) may still be required.

Some State water quality standards do not allow the use of mixing in the control of acute toxicity. For these States, acute toxicity is often limited at the end of the pipe. Permit limits derived to enforce such requirements would be considered "water quality-based" because they would be based upon an ambient criterion (as opposed to an arbitrary test endpoint). Regardless, both chronic and acute toxicity must be assessed in these situations.

Step 2: Toxicity Testing Procedures

Where toxicity tests are required in order to make decisions regarding appropriate next steps in a screening protocol, **EPA recommends as a minimum that three species (for example, a vertebrate, an invertebrate, and a plant) be tested quarterly for a minimum of 1 year.** As discussed in Chapter 1, the use of three species is strongly recommended. Experience indicates that marine algae can be a highly sensitive test species for some effluents. Using a surrogate species of the plant kingdom adds another trophic level to the testing regimen. For both freshwater and marine situations, the use of three species is more protective than two species since a wider range of species sensitivity can be measured. EPA is continuing to develop toxicity test methods using additional organisms including plants. In addition, EPA has revised the test for *Selenastnum*, which has improved the test precision.



where

$$CMC = 0.3\ TU_a$$

$$CCC = 1.0\ TU_c$$

Figure 3-4. Schematic Representation of Mixing Zone Areas Where the CMC and CCC Apply

EPA recommends against selecting a "most sensitive" species for toxicity testing. For one organism to consistently be the most sensitive in a battery of toxicity tests, two conditions must occur: (1) the toxicants causing toxicity must remain the same, and (2) the ratios of the toxicants in the effluent (if more than one) must remain the same. Based on EPA's experience at the Duluth research laboratory, neither of these conditions is likely to occur. For example, the causes of effluent toxicity in POTWs can vary on a seasonal basis. Toxicity in the summer can be caused by pesticides to which invertebrates are most sensitive. However, the winter toxicity could be caused by ammonia to which fathead minnows will respond most sensitively. The most sensitive species for an effluent actually may not exist and at best is difficult to identify.

Conducting toxicity tests using three species quarterly for 1 year is recommended to adequately assess the variability of toxicity observed in effluents. Below this minimum, the chances of missing toxic events increase. The toxicity test result for the most sensitive of the tested species is considered to be the measured toxicity for a particular effluent sample.

The data generation recommendations in Figure 3-2 represent minimum testing requirements. Since uncertainty regarding whether or not an effluent causes toxic impact is reduced with more data, **EPA recommends that this test frequency be increased where necessary to adequately assess effluent variability.** If less frequent testing is required in the permit, it is preferable to use three species tested less frequently than to test the effluent more frequently with only a single species whose sensitivity to the effluent is not well characterized.

EPA recommends that a discharger conduct <u>acute</u> toxicity testing if the dilution of the effluent is greater than 1000:1 at the edge of the mixing zone [3]. Such a discharger would be considered a low priority for chronic toxicity testing. The rationale for this is that the effluent concentration would be below 0.1 percent at the edge of the mixing zone and thus incapable of causing an excursion above the CCC. A worst case NOEC of 0.1 percent translates into 1,000 TU_c, which would result in a concentration of less than 1.0 TU_c at the edge of the mixing zone for this dilution category. The test results would be compared to the CMC after consideration of any allowable mixing.

EPA recommends that a discharger conduct either <u>acute or chronic</u> toxicity testing if the dilution of the effluent falls between 100:1 and 1,000:1 at the edge of the mixing zone. Effluents have been shown to be both acutely and chronically toxic within this range of receiving water dilution. Under worst-case scenarios, LC_{50}s of 1.0 percent and ACRs of 10 will result in excursions above both the CCC and CMC at the edge of the regulatory mixing zone.

Although either acute or chronic testing can be required within this dilution range, acute testing would be more appropriate at the higher end of this dilution range (1,000:1 or 0.1 percent). At the lower end of this dilution range (100:1 or 1.0 percent), chronic tests may be more appropriate. Where other factors are equal, chronic testing may be preferable since the interim results in a chronic test gives data on acute toxicity as well. The acute endpoint data can then be used to compare directly to the CMC without the need for an ACR.

Whichever type of toxicity test (either acute or chronic) is specified, the results from that test should be compared to the criterion associated with that type of test. For example, a chronic test would be compared to the CCC. Comparisons to the other criteria can be made by using the ACR or additional data generated to convert a chronic test result to an acute endpoint and vice versa. For example, a chronic NOEC of 5 percent effluent (or 20 TU_c) represents an acute LC_{50} of 50 percent (or 2 TU_a) at an ACR of 10.

EPA recommends that a discharger conduct chronic toxicity testing if the dilution of the effluent falls below 100:1 at the edge of the mixing zone. The rationale for this recommendation is that chronic toxicity has been observed in some effluents down to the 1.0 percent effect concentration. Therefore, chronic toxicity tests, although somewhat more expensive to conduct, should be used directly in order to make decisions about toxic impact.

There is a potential for acute toxicity within this dilution range, although this is less likely as the 100:1 dilution level is approached. Thus, the recommended screening protocol shown in Figure 3-2 includes a determination of whether excursions above the CMC are projected [4]. This analysis may be performed by assuming an ACR, applying this value to the chronic toxicity testing data, and allowing for any allowable initial mixing. Alternatively, the regulatory authority may use the interim results in the chronic test to calculate the acute toxicity.

Both the chronic and acute toxicity test data would be compared to their respective criterion. The chronic test results would be compared to the CCC, and the acute results, regardless of how calculated, would be compared to the CMC.

Step 3: Decision Criteria for Permit Limit Development

Once the toxicity data have been generated for a discharger, the regulatory authority must decide whether or not the results show that the permittee causes, has the reasonable potential to cause, or contributes to an excursion of an applicable numeric or narrative water quality criterion and therefore needs to limit effluent toxicity. To do this, these data should be used to project receiving water concentrations, which are then compared to the CCC and CMC. One of four outcomes will be reached when following the screening protocol shown in Figure 3-2:

1) <u>Excursion Above CMC or CCC</u>—Where any one data point shows an excursion above the State's numeric or narrative criterion for the parameter toxicity, EPA regulations require a permit limit be set for whole effluent toxicity (40 *CFR* 122.44(d)(1)(iv or v)), unless limits on a specific chemical will allow the narrative water quality criterion to be attained or maintained. In the absence of a State numeric criterion for the parameter toxicity, **EPA recommends that 1.0 TU_c and 0.3 TU_a be used as the CCC and CMC, respectively.** The decision to develop permit limits based upon an excursion above either the CMC or CCC will lead to protection against both acute and chronic toxicity if the permit derivation procedures in Chapter 5 are used to set effluent limits.

2) <u>Reasonable Potential for Excursion Above CMC or CCC</u>—**EPA believes that "reasonable potential" is shown where an effluent is projected to cause an excursion above the CCC or CMC. This projection is based upon a statistical analysis of available data that accounts for limited sample size and effluent variability.** EPA's detailed recommendations for making a statistical determination based upon effluent monitoring data alone are shown in Box 3-2. Where a regulatory authority finds that test results alone indicate a "reasonable potential" to cause an excursion above a State water quality criterion in accordance with 40 *CFR* 122.44(d)(1)(ii), a permit limit must be developed.

   A regulatory authority may select an alternative approach for assessing reasonable potential. For example, an authority may opt to use a stochastic dilution model that incorporates both ambient dilution and effluent variability for determining reasonable potential. Such an approach is analogous to the statistical approach shown in Box 3-2. Whatever approach selected by the authority, it must use all the factors that account for all the factors listed in 40 *CFR* 122.44(d)(1)(ii).

   In some cases the statistical analysis of the effluent data may not actually project an excursion above the CMC or CCC but may be close. Under such conditions, reasonable potential determinations will include an element of judgment on the part of the regulatory authority. Other factors will need to be considered and given appropriate weight in the decisionmaking process, including value of waterbody (e.g., high-use fishery), relative proximity to the CCC or CMC, existing controls on point and nonpoint sources, information on effluent variability, compliance history of the facility, and type of treatment facility. These factors are summarized in Box 3-2 and are discussed in detail in Section 3.1. **EPA recommends regulatory authorities establish a written policy and procedure for making determinations of "reasonable potential" under these circumstances.**

3) <u>No Reasonable Potential for Excursions Above CMC or CCC</u>—In these situations, **EPA recommends that the toxicity tests recommended above be repeated at a frequency of at least once every 5 years as a part of the permit application.** Such testing is required for certain POTWs under 40 *CFR* 122.21(j).

4) <u>Inadequate Information</u>—Where a regulatory authority has inadequate information to determine reasonable potential for an excursion of a numeric or narrative water quality criterion, there may still be a basis for concern on the part of the authority. The permit should contain whole effluent toxicity monitoring requirements and a reopener clause. This clause would require reopening of the permit and establishment of a limit based upon any test results, or other new factors, which substantiate that the effluent causes, has the reasonable potential of causing, or contributes to an excursion above the CCC or CMC.

3.3.4 Use of Toxicity Testing in Multiple-source Discharge Situations

Where more than one discharge to the same receiving waterbody contributes, or has the reasonable potential to contribute to an excursion of water quality standards, permit limits must be developed for each individual discharger on that waterbody. For the regulatory authority to make this assessment, additional testing may be needed to provide the authority with the information necessary to assess the relative impact of each source. For purposes of this discussion, a multiple-source discharge situation is defined as a situation where impact zones overlap, or where ambient receiving water concentrations of a pollutant are elevated due to upstream discharges. In multiple-source discharge situations, additivity, antagonism, and persistence of toxicity can be of concern. To collect additional data, the permit authority should employ the toxicity testing procedures for multiple dischargers described in Box 3-3. In addition, ambient toxicity testing, as described below, could be used.

Assuming that screening has been conducted that reveals the need for permit limits, two options for controlling the discharges exist. The first option is for the permit authority to regulate each source separately using the procedures for individual point sources. In this option, the permitting authority would require use of upstream ambient water as a diluent in the toxicity test so as to be able to evaluate the contributions of upstream sources of toxicity. A second option is to treat each discharge as an interactive component of a whole system. In this option, the permit writer would determine a total maximum daily load for the receiving waterbody and develop individual wasteload allocations for each discharger using the procedures discussed in Chapter 4.

Box 3-3. Recommend Multiple-source Toxicity Testing Procedures

Tests

Where the combined effluents make up 1 percent or greater of the receiving waters, conduct chronic toxicity tests following the testing procedures described in Section 3.3.3.

Where the combined effluents make up less than 1 percent of the receiving waters, conduct acute toxicity tests following the testing procedures described in Section 3.3.3 (see Figure 3-2) to determine if any of the effluents are exhibiting toxicity.

An additional data requirement is the assessment of relative and absolute toxicity of each source so that appropriate permit conditions can be set for individual dischargers. The following procedure is suggested.

1) Conduct one set of toxicity tests on the effluents using a control of reconstituted or uncontaminated dilution water. The set of tests will give an absolute toxicity measurement of the effluent.

2) Run a parallel set of toxicity tests on the effluent using dilution water taken directly upstream from the point of discharge or, for estuarine waters, from an area outside of the immediate discharge impact zone (this will have to be determined by a dye study). This dilution water may be contaminated with upstream effluents or other toxicant sources. The purpose of this test is to project toxic impact of the effluent after it is mixed at its point of discharge. This is a relative effluent toxicity measurement. The relative testing procedure could result in a change in the standard concentration-effect curve generated by the testing. The dilution water for the relative toxicity test may cause significant mortality, growth, or reproductive effects at the lower effluent concentrations (including the 100 percent diluent control concentration) if the diluent from the receiving water is toxic (from an upstream discharge). Such mortality does not invalidate the test. Instead, analysis of toxicity trends resulting from the relative toxicity tests can be used to assess the effluent's toxicity in relation to other sources and ambient receiving water conditions. However, a control dilution water with no toxicity must be used for quality assurance and determination of absolute toxicity of the effluent.

3) Conduct ambient toxicity tests to (a) determine whether or not the effluent has a measurable toxicity after mixing, (b) measure persistence of toxicity from all sources contributing to receiving water toxicity, and (c) determine combined toxicity resulting from the mixing of multiple, point, and nonpoint sources of toxicity. See Appendix C for a discussion of ambient toxicity testing procedures.

The ambient testing can be required of each discharger and conducted during low-flow or worst-case design periods.

Frequency for Ambient Testing

All testing should be conducted simultaneously by each discharger, if possible. At a minimum, the tests should be conducted concurrently starting within a short time period (1 to 2 days). Repeated ambient toxicity analyses will be desirable when variable effluents are involved. Effluent toxicity data showing variability can be used to assess what frequency will be most applicable. The level of repetition for variability analysis should be similar to that used in effluent variability analyses.

Other Considerations

Dye studies of effluent dispersion for rivers, lakes, reservoirs, and estuaries are strongly recommended. This allows analysis of effluent concentration at the selected sampling stations above and below the discharge points.

The procedures suggested in this multiple source section are based on actual multiple source site investigations conducted under the Complex Effluent Toxicity Testing Program. Site reports from that study can be used to obtain further description of the toxicity testing procedures used to analyze multiple source toxic impact [1, 2].

3.3.5 *Ambient Toxicity Testing*

Ambient toxicity testing also is useful in screening receiving water bodies for existing toxic conditions. The procedure described in Appendix C uses short-term chronic toxicity tests to measure the toxicity of samples of receiving water taken above, at, and below outfalls. It can be used in freshwater, marine, and estuarine systems. The procedure must be conducted during an appropriate low-flow or worst-case design period.

The utility of the ambient toxicity screening approach is that actual receiving water toxicity is directly measured. No extrapolation from exposure or ACR is needed. Further, impact from multiple source discharge situations, which may not be apparent from individual discharger data, is identified. Finally, the technique can provide an assessment of the persistence of effluent toxicity.

3.3.6 *Special Considerations for Discharges to Marine and Estuarine Environments*

Special problems are encountered when assessing and controlling impacts of toxic pollutants discharged to marine and estuarine waterbodies. These special problems include the following:

- Determining the physical characteristics of estuaries and the complex mixing and effluent dilution situations for RWCs of effluents.
- Generating toxicity data on nonsaline effluents that discharge to brackish or saline waters and establishing cause-effect relationships on that basis.
- Assessing exposure and controlling impacts from persistent toxicants accumulating in fish and shellfish tissues and in sediments. These factors are particularly important in estuaries and near coastal waters because of high use of estuaries as breeding and fishing areas for important commercial seafood supplies and recreational fishing, and because many estuaries and near coastal waters act as sinks for pollutants that accumulate in sediments.

Where these special problems are encountered, additional information may need to be gathered to better quantify dilution, to determine metals partitioning, and to identify potential interferences in whole effluent toxicity tests.

To characterize the type of whole effluent toxicity that is most relevant for a particular discharge to marine and estuarine waters, the following questions should be considered [5]:

- What is the salinity of the receiving water, and is this important in terms of the State standards?
- What is the appropriate test organism to require for toxicity testing under differing salinity conditions?

The answers to these questions will enable the permitting authority to determine what type of toxicity testing is most suitable for effluent characterization and whole effluent toxicity control.

For most marine and estuarine discharges the choice of test species and dilution water should be made based on the characteristics of the receiving water at the critical conditions for flow, mixing, and salinity. Foremost in this determination should be the salinity of the receiving water and, to a lesser extent, the salinity of the effluent itself.

The primary objective of whole effluent toxicity tests is to identify sources of toxicity that can potentially cause an excursion of a State's narrative or numeric water quality criteria. For this reason, the toxicity tests should reflect the natural conditions of the receiving water so to be able to measure any effluent characteristic that could contribute to ambient toxicity. The marine toxicity test methods identify 1,000 mg/l as the point at which salinity begins to exert an effect on freshwater species. **As a general rule, EPA recommends that freshwater organisms be used when the receiving water salinity is less than 1,000 mg/l, and that marine organisms be used when the receiving water salinity equals or exceeds 1,000 mg/l.**

Saline Effluent Discharges to Saltwater

The dissolved salts in the effluent are pollutants. These salts may or may not be the same as those present in the receiving water. Also, the proportion of dissolved salts in the effluent may be different from that of the salts in the receiving water. In this case, the toxicity test needs to be able to determine if these salts contribute to ambient toxicity. For this reason, marine organisms are needed.

Saline Effluent Discharged to Freshwater

In this case, the dissolved salts in the effluent is a pollutant that does not exist in the receiving water. The toxicity test needs to determine whether the dissolved salts can be one of the toxicants that contribute to ambient toxicity. For this reason, freshwater organisms are needed.

Freshwater Effluent Discharged to Saltwater

In this instance, the lack of dissolved salts in the effluent can cause an apparent toxic effect to the marine organisms in the toxicity test. However, in contrast to the instances presented above, the toxicity test does not need to be able to measure this effect because a lack of salts is not a pollutant. The marine toxicity test methods account for this by requiring that the salinity of the effluent be adjusted to approximate the salinity of the receiving water. As an alternative to using a marine organism, a freshwater organism can be used if the test is being conducted only on a 100-percent effluent sample and if State water quality standards do not require that a marine organism be used.

3.3.7 *Using a Chemical-specific Limit to Control Toxicity*

EPA regulations at 40 *CFR* 122.44(d)(1)(v) provide that limits on whole effluent toxicity are not necessary where the permitting authority demonstrates in the fact sheet or statement of basis of the NPDES permit that chemical-specific limits for the effluent are sufficient to attain and maintain applicable numeric and narrative State water quality criteria. To make this demonstration that chemical-specific limits are sufficient, additional effluent information will be needed. **EPA recommends that the discharger conduct a toxicity identification evaluation to identify the causative agent(s) in the effluent.** Where the permitting authority determines that the demonstration required by 40 *CFR* 122.44(d)(1)(v) has been made, limits on whole effluent toxicity need not be imposed. Effluent limits on the controlling chemical with concurrent whole effluent monitoring will be sufficient. Where subsequent whole effluent toxicity testing reveals the presence of toxicity in the effluent, the above process will need to be repeated, or alternatively a whole effluent toxicity limit will be needed. If continued toxicity testing shows that additional chemical-specific effluent limits are insufficient to control whole effluent toxicity, then toxicity limits may be the only practical way to control toxicity.

3.3.8 Effluent Characterization for Specific Chemicals

The previous section discussed effluent characterization for whole effluent toxicity. This section will describe EPA's recommendations for data generation to determine whether or not permit limits are needed to control specific chemical pollutants in effluents. While many of the same principles apply when developing chemical-specific limits, there are some differences based upon regulatory and analytical considerations.

Characterization of impacts due to specific chemicals do not require a determination of the type of testing as is required for whole effluent toxicity because there is generally only one type of test for specific chemicals. However, there are some antecedent steps that are unique to effluent characterization for specific chemicals: determination of the chemicals of concern and determination of acceptable ambient levels (RAC, CMC, or CCC) for these pollutants.

Steps for Chemical-specific Effluent Characterization Process

Figure 3-5 illustrates EPA's recommendations for determining whether or not permit limits need to be developed according to an evaluation of a limited data set. The following discussion corresponds to the various activities shown in Figure 3-5. (Refer to the human health discussion in Section 3.3.9 for additional details on procedures to characterize the bioconcentration potential of effluents.)

Step 1: Identify the Pollutants of Concern

This process should begin with an examination of existing data to determine the presence of specific toxicants for which criteria, standards, or other toxicity data are available. Sources of data include the following:

- Permit application forms, DMRs, permit compliance systems (PCS), and permit files
- Pretreatment industrial surveys
- STORET for ambient monitoring data
- SARA Title III Toxic Chemical Release Inventory
- Industrial effluent guidelines development documents
- The Treatability Manual [6]
- Effluent bioconcentration assessment (see Section 3.3.9).

Data on specific chemicals that are typically submitted with NPDES application forms will consist of a limited number of analytical test results for many of the reported parameters. Where the regulatory authority has reason to believe that additional data for key parameters of concern are needed in order to adequately characterize the effluent, this information should be requested as a part of the application or, in some cases, through the use of Section 308 letters. **It is recommended that 8 to 12 samples be analyzed for key parameters of concern.** In some cases, special analytical protocols will need to be specified in order to gather all appropriate information.

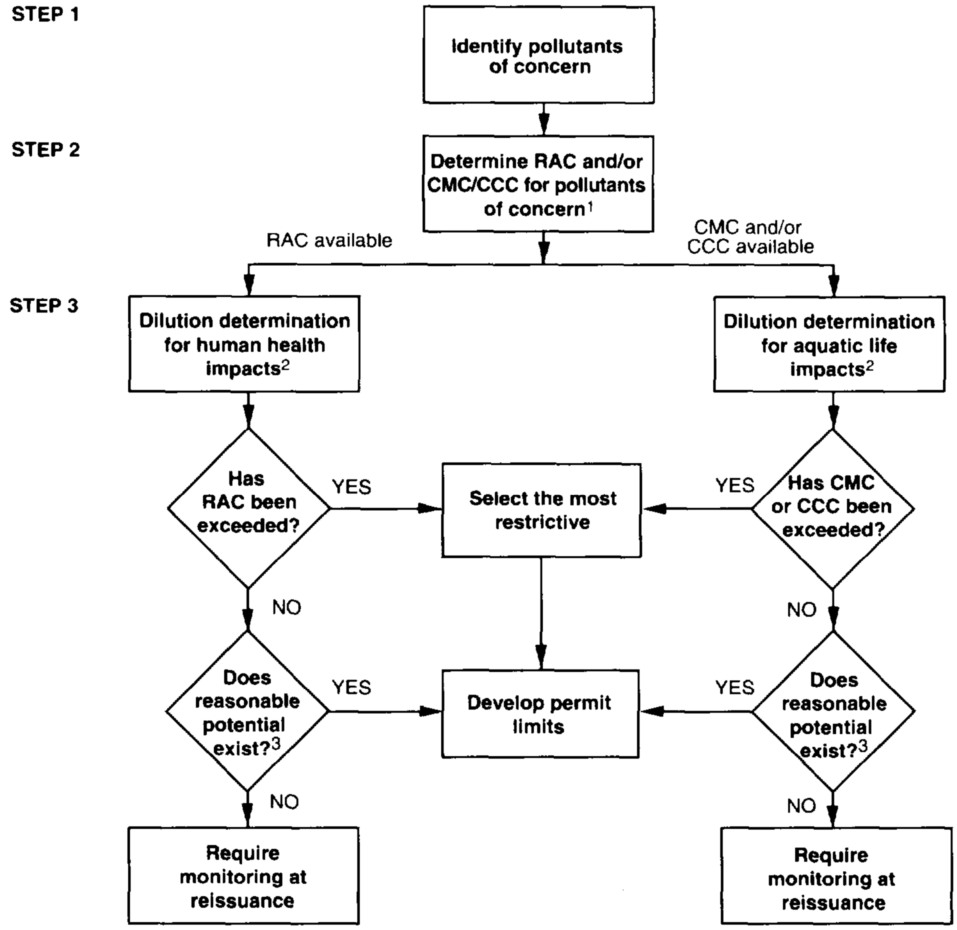
Step 2: Determine the Basis for Establishing RACs, CMCs, and CCCs for the Pollutants of Concern

The second step is to identify the appropriate water quality standard, including designated or existing use, and criteria for use. Ideally, the State water quality standards include aquatic life and human health criteria for the pollutants of concern. If a State does not have a numeric water quality criterion for the pollutant of concern, then one of three options for using the narrative criterion may be used (40 *CFR* 122.44(d)(1)(vi)) to determine whether a discharge causes, has the reasonable potential to cause, or contributes to an excursion above a narrative criteria because of an individual pollutant. Although the provisions of 40 *CFR* 122.44(d)(1)(vi) are presented in the regulation in the context of permit limit development, these same considerations should be applied in characterizing effluents in order to determine whether limits are necessary. The options available are as follows:

- **Option A** allows the regulatory authority to establish limits using a "calculated numeric water quality criterion" that the regulatory authority demonstrates will attain and maintain applicable narrative water quality criteria and fully protect the designated use. This option allows the regulatory authority to use any criterion that protects aquatic life and human health. This option also allows the use of site-specific factors, including local human consumption rates of aquatic foods, the State's determination of an appropriate risk level, and any other current data that may be available.

- **Option B** allows the regulatory authority to establish effluent limits using EPA's Water Quality Criteria guidance documents, if EPA has published a criteria document for the pollutant supplemented where necessary by other relevant information. As discussed earlier, EPA criteria documents provide a comprehensive summary of available data on the effects of a pollutant.

- **Option C** may be used to develop limits for a pollutant of concern based on an indicator parameter under limited circumstances. An example of an indicator parameter is total toxic organics (TTO); effluent limits on TTO are useful where an effluent contains organic compounds. However, use of this option must be justified to show that controls on one pollutant control one or more other pollutants to a level that will attain and maintain applicable State narrative water quality criteria and will protect aquatic life and human health (see 40 *CFR* 122.44(d)(1)(vi)(C)). Use of this option is restricted by regulation to those instances where it can be demonstrated that controls on indicator pollutants serve to control the toxicant of concern. Using Option A or Option B is a more direct and perhaps more defensible approach.



Notes:

[1] RAC and/or CMC/CCC: Use State numeric criterion or interpret State narrative criterion using one of three options specified under 40 *CFR* 122.44(d).

[2] Dilution determination: Perform for critical flow and for any applicable mixing zones for aquatic life and human health protection procedures, respectively.

[3] Reasonable potential: Use procedures in Boxes 3-2 and 3-4.

Figure 3-5. Effluent Characterization for Specific Chemicals

Step 3: Dilution Determination

The third step is to calculate the effluent dilution at the edge of the mixing zone. The pertinent factors for consideration here are the same as were previously presented for whole effluent toxicity with one difference: there are two levels of dilution analysis for chemical data. The first level is to use simple fate models based on a dilution analysis and comparison with the RAC, CMC, or CCC. The second level of analysis is to use more complex fate models, including dynamic models to estimate persistence, and may be applied to lakes, rivers, estuaries, and coastal systems using a desktop calculator or microcomputer. EPA has supported development of a second level of analysis that estimates point source wasteload allocations and nonpoint source allocations and predicts the resulting pollutant concentrations in receiving waters [7].

Step 4: Decision Criteria for Permit Limit Development

After this dilution analysis has been performed, the projected RWC is compared to the RAC, CMC, or CCC (either the State numeric criteria or an interpretation of the narrative criteria as described earlier). Whereas analysis of aquatic impacts should include evaluations with respect to both the CCC and the CMC, analysis of human health impacts will only involve comparisons with the RAC. The four possible outcomes discussed above in the triggers for permit limit development discussion in Section 3.3.3 also apply here:

- Excursion above the RAC, CMC, or CCC
- Reasonable potential for excursion above the RAC, CMC, or CCC

- No reasonable potential for excursion above the RAC, CMC, CCC
- Inadequate information.

If these evaluations project excursions or the reasonable potential to cause or contribute to an excursion above the RAC, CMC, or CCC, then a permit limit is required (40 *CFR* 122.44(d)(1)(iii)). The statistical approach shown in Box 3-2 or an analogous approach developed by a regulatory authority can be used to determine the reasonable potential. Effluents that are shown not to cause or that have a reasonable potential to cause or contribute to an excursion above an RAC, CMC, or CCC should be reevaluated at permit reissuance.

Where chemical-specific test results do not show a reasonable potential but indicate a basis for concern after consideration of the other factors discussed in Section 3.2, or if there were inadequate information to make a decision, the permit should contain chemical testing requirements and a reopener clause. This clause would require reopening of the permit and establishment of a limit based upon any test results that show effluent toxicity at levels that cause or have a reasonable potential to cause or contribute to an excursion above the RAC, CCC, or CMC.

3.3.9 Effluent Characterization for Bioconcentratable Pollutants

The previous section discussed how to characterize effects of specific chemicals, including those that may threaten human health, to determine whether or not a discharge causes, has the reasonable potential to cause, or contributes to excursions above an water quality criterion. The primary disadvantage of this approach is that it does not identify all effluent chemicals of potential concern for human health. To help address this gap, EPA is developing a procedure for identifying pollutants with the propensity to bioconcentrate in fish tissue. This procedure is presently in draft form and should not be used for establishing NPDES permit limits until EPA releases the final document on the procedure. This section describes the outline of this procedure.

The overall approach illustrated in Figure 3-6 is a seven-step procedure that starts with collecting samples and ends with developing permit effluent limits. The effluent characterization step unique to this approach lies in Step 3. There are two alternatives under this step: fish tissue residue and effluent assessment. An analytical chemistry laboratory with residue chemistry and gas chromatograph/mass spectometer (GC/MS) capability is needed to conduct the analytical methods for both alternatives. A summary of the alternatives follows:

- Tissue Residue Alternative: This alternative measures the concentrations of organic bioconcentratable chemicals in tissue samples of indigenous organisms from the receiving water. This analysis involves the collection of fish or shellfish samples, the extraction of the organic chemicals from the tissue and the analysis of these extracts with GC/MS to identify and quantify the bioconcentratable contaminants. The procedure provides recommendations to sort the results of this screening analysis in order to determine which of the contaminants pose a hazard and require regulatory action. The approach recommends that the identity of those contaminants then be confirmed prior to taking subsequent action.

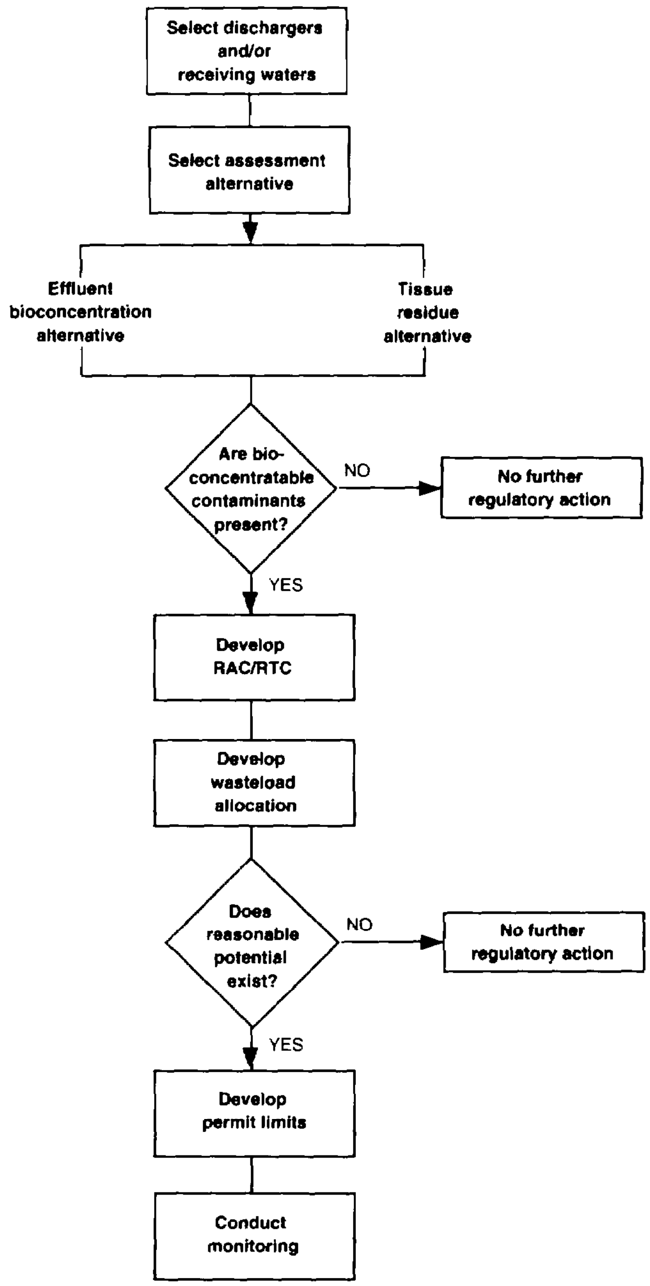


Figure 3-6. Procedure for Assessment and Control of Bioconcentratable Contaminants in Surface Waters

- Effluent Alternative: This alternative measures the concentrations of organic bioconcentratable chemicals in effluent samples from point source dischargers. This analysis involves the collection of effluent samples, the extraction of the organic chemicals from the effluent sample, and the separation of the chemicals that have characteristics known to result in bioconcentration from the other chemical components of the effluent sample. This separation is achieved by way of an analytical chemistry methodology called highpressure liquid chromotography (HPLC). The HPLC also separates (fractionates) an effluent sample into three subsamples or "fractions." These three fractions contain chemicals with increasing potential to bioconcentrate, with the third fraction containing those chemicals with the highest bioconcentration rates. Following HPLC fractionation, each fraction is then analyzed with GC/MS to identify and quantify the bioconcentratable contaminants. The effluent procedure also provides recommendations to sort the results of the initial screening analysis to determine which of the contaminants pose a hazard and require subsequent regulatory action. The approach then recommends that the identity of those contaminants then be confirmed prior to taking further regulatory action.

While both of the assessment alternatives described above may be used for a given discharger, generally one of these alternatives may be preferred by the regulatory authority. The regulatory authority would select the assessment approach based on the available site- and facility-specific information and the objectives of the application.

Although the approach provides a means to identify chemicals that can bioconcentrate, it does not identify all bioconcentratable chemicals. Chemicals that bioconcentrate include many organic compounds, and a small number of metals (e.g., mercury and selenium) and organometals (e.g., tributyltin). The new approach is limited to nonpolar organic chemicals that produce measurable chemical residues in aquatic organisms or that have log octanol-water partition coefficients greater than 3.5.

3.3.10 Analytical Considerations for Chemicals

Analysis of discharges for toxic substances requires special quality control procedures beyond those necessary for conventional parameters. Toxicants can occur in trace concentrations and are frequently volatile or otherwise unstable. An EPA publication entitled, *Test Methods—Technical Additions to Methods for Chemical Analysis of Water and Wastes* [8], contains sampling and handling procedures recommended by EPA for a number of toxic and conventional parameters. Additional methods for analyses for toxicants are described in Standard Methods of Water and Wastewater Analyses (ASTM, 17th edition, 1989, or most recent edition) and 40 CFR Part 136. Chapter 5 discusses detection limits and sampling requirements.

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Spokane River
PCB Source Assessment
2003-2007

DEPARTMENT OF
ECOLOGY
State of Washington

April 2011
Publication No. 11-03-013

Publication and Contact Information

This report is available on the Department of Ecology's website at
www.ecy.wa.gov/biblio/1103013.html

Data for this project are available at Ecology's Environmental Information Management (EIM) website www.ecy.wa.gov/eim/index.htm. Search User Study ID, DSER0010.

The Activity Tracker Code for this study is 09-234.

For more information contact:

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Cover photo: Spokane Falls (photo by Pat Hallinan)

Spokane River
PCB Source Assessment
2003-2007

by

Dave Serdar, Brandi Lubliner, Art Johnson, and Dale Norton

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Environmental Assessment Program
Washington State Department of Ecology
Olympia, Washington 98504-7710

Waterbody Numbers:

WA-57-1010: Middle Spokane River
WA-54-1010, WA-54-1020: Lower Spokane River
WA-54-9040: Lake Spokane (formerly Long Lake-Spokane River)
WA-55-1010: Little Spokane River

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Abstract

The Spokane River does not meet Washington State human health criteria for polychlorinated biphenyls (PCBs) in edible fish tissue. During 2003 to 2007, the Department of Ecology conducted a series of water quality studies in an effort to assess sources of these legacy pollutants to the river. PCBs were analyzed in river water, industrial and municipal wastewater effluents, stormwater, suspended particulate matter, bottom sediments, sediment cores, and fish tissue. The study area covered the Spokane River from the Idaho border (river mile 96.1) to the mouth at the Columbia River. The lower part of the river flows through the Spokane Tribe of Indians reservation.

Total PCB concentrations in water increased with successive reaches moving downstream from the Idaho border (106 pg/l, parts per quadrillion) to lower Lake Spokane (formerly Long Lake; 399 pg/l), with a corresponding eight-fold increase in loads (477 – 3,664 mg/day), on average. The Washington State PCB human health criterion for surface water is 170 pg/l. Although PCB concentrations in Spokane River fish are generally much lower than historical levels, fish in most areas did not meet the state's human health criterion in edible tissue (5.3 ng/g, parts per billion).

Overall, PCB loading to Washington reaches of the river can be divided into the following source categories; City of Spokane stormwater (44%), municipal and industrial discharges (20%), and Little Spokane River (6%). In addition, PCB loading from Idaho at the state line represented 30% of the overall loading.

A PCB loading scenario was proposed to meet the Spokane Tribe human health water quality criterion for total PCBs (3.37 pg/l, equivalent to 0.1 ng/g in tissue). The scenario requires a 95% PCB load reduction at the Idaho border, a 97% load reduction in the Little Spokane River, and ≥99% reductions in municipal, industrial, and stormwater discharges. A food web bioaccumulation model indicated that PCB loads in water and PCB concentrations in sediment would require large reductions to meet the Spokane Tribe criterion.

Acknowledgements

The authors of this report thank the following people for their contribution to this study:

- Pat Blau (Kaiser Trentwood), Rick Fink (Inland Empire), Dan Grogg (Liberty Lake Wastewater Treatment Plant), and Tim Pelton (Spokane Wastewater Treatment Plant) permitted sampling of their facilities.
- Gary Bussiere and Michael Coster (City of Spokane) arranged and conducted stormwater sampling.
- Bob Hughes (Plante Ferry Park), Dennis Dalton, Jack Hartt, and Mark Nickelson (Riverside State Park), Brett Walker (Washington Department of Natural Resources Long Lake Campground), Mark Bloss and Larry Ford (Avista Long Lake and Little Falls Dam), and Mark Cleveland (Upriver Dam) provided access to the Spokane River.
- John Sneva and Lucinda Morrow (Washington Department of Fish and Wildlife) aged fish specimens.
- Jim Huckins and David Alvarez (U.S. Geological Survey) provided advice on interpreting semipermeable membrane devices data.
- Larry Gadbois (Environmental Protection Agency) reviewed the report.
- Staff from the Washington State Department of Ecology (* formerly with Ecology):
    - John Roland of Ecology's Eastern Regional Office (ERO) provided valuable advice from project inception through completion.
    - John Roland, David Moore, Patrick Hallinan, Arianne Fernandez, and Brendan Dowling reviewed the project report for ERO.
    - Nigel Blakley*, Brandee Era-Miller, Richard Jack*, Aspen Madrone, Dale Norton, Jim Ross, Lawrence Sullivan*, and Sandra Treccani assisted with sampling.
    - Steve Golding* conducted sampling at NPDES permitted facilities.
    - Chad Wiseman* identified benthic organisms in fish stomachs.
    - Nigel Blakley* assisted with food web modeling.
    - Casey Deligeannis and Keith Seiders helped prepare tissue samples.
    - Pam Covey* and Will White* tracked and transported samples for laboratory analysis.
    - Karin Feddersen managed outside laboratory contracts.
    - Heidi Chuhran, Kamilee Ginder, Meredith Jones, Randy Knox, Myrna Mandjikov, Jamie Martin, Bridget Mason, Dean Momohara, and Aileen Richmond analyzed samples at Manchester Environmental Laboratory.
    - David Sternberg reviewed the project report for the Toxics Cleanup Program.
    - Dale Norton supervised this project.
    - Joan LeTourneau, Cindy Cook, and Gayla Lord edited and formatted the final report.

Executive Summary

Section 303(d) of the federal Clean Water Act requires states to prepare a list every two years of waterbodies that do not meet water quality standards. In Washington, the 303(d) list is compiled by the Washington State Department of Ecology (Ecology). The Clean Water Act requires that waterbodies on the 303(d) list be cleaned up by pollution-control programs or that a Total Maximum Daily Load (TMDL) be developed for the pollutants of concern. A TMDL determines the amount of pollutant that can be discharged to a waterbody and still meet standards (loading capacity) and allocates that load among the various sources."

Fifteen waterbody segments of the Spokane River and Lake Spokane (also known as Long Lake), and one segment of the Little Spokane River are on the 2008 303(d) list for not meeting (exceeding) Washington State's human health water quality criterion for polychlorinated biphenyls (PCBs) in edible fish tissue (Table ES-1). PCBs are legacy pollutants no longer produced or no longer put into new use in the United States. PCBs had numerous industrial applications as insulating fluids, plasticizers, in inks, and carbonless paper, and as heat transfer and hydraulic fluids. Environmental Protection Agency (EPA) has classified these compounds as probable human carcinogens.

Table ES-1. 303(d) Listings for Total PCBs in the Spokane River.

Waterbody	Reach	Waterbody Number	Watercourse Number	Listing ID
Spokane River	Idaho Border to Latah Creek	WA-57-1010	QZ45UE	14397 14398 8201 8207 8202 14402
Spokane River	Latah Creek to Ninemile Dam	WA-54-1010	QZ45UE	14400 14385 9033
Little Spokane River	Near mouth	WA-55-1010	JZ70CP	9051
Lake Spokane (Long Lake)	Ninemile Dam to Lake Spokane Dam	WA-54-9040	QZ45UE	9021 36441 9015 36440
Spokane River	Lake Spokane Dam to Mouth	WA-54-1020	QZ45UE	9027

Ecology conducted the water quality studies described in this report from 2003 to 2007 to assess PCB sources to the Spokane River. The goal of these efforts was to quantify PCB contamination and identify necessary reductions in sources and the receiving waters to meet applicable PCB water quality criteria in the Spokane River. The studies analyzed PCBs in river water, industrial and municipal effluents, stormwater, suspended particulate matter, bottom sediments, sediment cores, and fish tissue.

The Spokane River, shown in Figure ES-1, begins in northern Idaho at the outlet of Lake Coeur d'Alene and flows west 112 miles to the Columbia River (Lake Roosevelt). The study area covered the Spokane River from the Idaho border (river mile 96.1) to the Columbia. The watershed encompasses over 6,000 square miles (15,500 km^2) in Washington and Idaho. The river flows through the smaller cities of Post Falls and Coeur d'Alene in Idaho and large urban areas of the Spokane Valley and Spokane in Washington. Other cities in the watershed include Liberty Lake, Deer Park, and Medical Lake Washington as well as Wallace and Kellogg Idaho upstream from Lake Coeur d'Alene. The Spokane Tribe of Indians reservation lies along the north bank of the lower river (Spokane Arm of Lake Roosevelt).

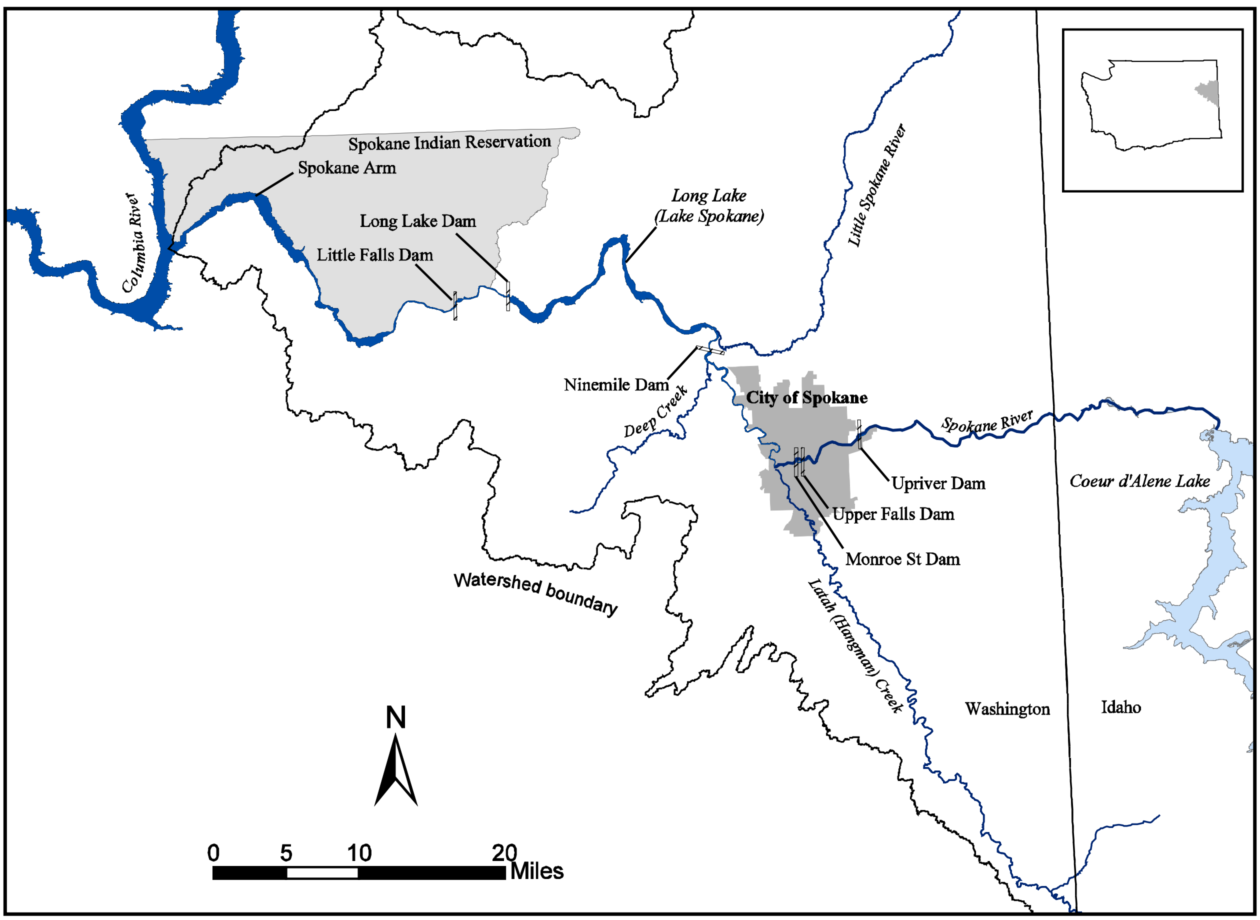

Figure ES-1: Spokane River Basin.

The Spokane Tribe human health PCB water quality criterion of 3.37 pg/l (parts per quadrillion) was used as the basis for calculating necessary PCB load reductions. The criterion is equivalent to 0.1 ng/g (parts per billion) in edible fish tissue. Although this criterion only applies to the Spokane Arm and lower half of the Little Falls reservoir, it cannot reasonably be met within these bounds unless PCB concentrations in upstream reaches are reduced to levels near the criterion. Washington State's human health criteria for PCBs is 170 pg/l (5.3 ng/g in fish tissue), the difference primarily being due to assumptions about human consumption rates of fish.

A PCB loading scenario is proposed to meet the Spokane Tribe human health criterion. The scenario requires a 95% PCB load reduction at the Idaho border, a 97% load reduction in the Little Spokane River, and ≥99% reductions in municipal, industrial, and stormwater discharges. Based on the loads estimated in this report, the largest current contributor of PCBs to the river (44%) is the City of Spokane's partially combined sewer-stormwater system. This is the most important source to reduce.

A food web bioaccumulation model used to predict PCB concentrations in fish tissue from the levels in water and sediments indicates that reductions of ≥99% would be required to meet the Spokane Tribe's fish tissue criterion where the Spokane River enters the reservation. Even with large reductions in PCBs, it seems unlikely that the Spokane tribal target (0.1 ng/g) in fish tissue is achievable. This concentration is approximately an order of magnitude lower than the median level (1.4 ng/g) reported in fish tissue from background areas of Washington in a 2010 statewide study conducted by Ecology (Johnson et al., 2010). Despite the extremely low tribal criteria, it is clear that further reductions in PCB loading are achievable. Implementing an adaptive management narrative limit in National Pollutant Discharge Elimination System (NPDES) permits might be a productive approach to establish a set of achievable targets for toxic chemical reductions.

Recommendations

Even though significant reductions in PCB levels have been measured in the Spokane River over the last two decades, achieving further reductions in PCBs will be a challenging long-term process which will require a strategy that uses a combination of activities to achieve water quality targets. To start meeting this challenge, Ecology has drafted a long-term strategy for reducing PCBs and other toxic chemicals in the Spokane River watershed.

The Spokane River Toxics Reduction Strategy requires coordination across several Ecology programs, including the Spokane River Urban Waters Program (UWP) which was formed in 2007. The primary purpose of this program is to identify and eliminate toxic chemicals at their source. The UWP also works cooperatively with local governments including the City of Spokane and the Spokane Regional Health District.

Under the reduction strategy, source identification and control will largely be carried out by the UWP. The strategy uses a three-pronged approach (prevention, management, and cleanup) to reduce sources. Priority is placed on using a systematic step-wise process for identifying potential PCB sources within a conveyance system, then reducing and/or eliminating sources as they are located.

The conceptual approach to reduce PCBs discharged to the Spokane River should continue to focus on:

1. Identifying PCB sources and reducing or eliminating them from stormwater and wastewater effluents.
2. Examining treatment alternatives for effluent PCB removal.
3. Implementing necessary treatment plant controls.
4. Characterizing PCB transport through groundwater.

Implementation of an adaptive management approach using narrative limits in NPDES permits should be explored as an option to establish a set of achievable targets for toxic chemical reductions. In addition, source reduction efforts should be coupled with an ongoing effectiveness monitoring program to evaluate progress in reaching water quality targets.

The 303(d) List

The federal Clean Water Act established a process to identify and clean up polluted waters. The Clean Water Act requires each state to have its own water quality standards designed to protect, restore, and preserve water quality. Water quality standards include (1) designated uses for aquatic life, recreation, water supply, and harvesting (fish consumption) and (2) criteria, usually numeric criteria, to protect those uses.

Every two years, states are required to prepare a list of waterbodies – lakes, rivers, streams, or marine waters – that do not meet water quality standards. This list is called the 303(d) list and is prepared by the Washington State Department of Ecology (Ecology). To develop the list, Ecology compiles its own ambient water quality data along with data from local, state, and federal governments, tribes, industries, and citizen monitoring groups. All data are reviewed to ensure that they were collected using appropriate scientific methods before being used to develop the 303(d) list. The 303(d) list is part of the larger Water Quality Assessment (www.ecy.wa.gov/programs/wq/303d/index.html).

The last comprehensive freshwater and marine water 303(d) list for Washington was prepared in 2008. Listing updates are now staggered, with the marine list completed in 2010 and the freshwater list scheduled to be completed in 2012. The next opportunity to evaluate compliance with water quality standards in the Spokane River will be in 2012.

The Clean Water Act requires that waterbodies on the 303(d) list be cleaned up by pollution-control programs or that a TMDL be developed. A pollution-control program needs to address the sources of pollution and have a monitoring and enforcement component. A TMDL identifies pollution problems in the watershed and specifies how much pollution needs to be reduced or eliminated to achieve clean water. When developing a pollution-control program or a TMDL, Ecology works with the local communities and other relevant stakeholders to identify all actions that need to occur to address the sources of pollution. A monitoring plan to assess the effectiveness of those implementation actions is also developed. That monitoring plan is used to determine success or the next steps needed.

Spokane River PCB Listings

The Spokane River begins in northern Idaho at the outlet of Lake Coeur d'Alene and flows west 112 miles to the Columbia River. Within Washington this includes Water Resource Inventory Areas (WRIAs) 54, 55, 56, and 57 (Figure 1). The designated uses for this area include aquatic life uses, recreation, fish consumption, and Spokane Tribe of Indians ceremonial, spiritual, and cultural uses (see *Water Quality Standards and Designated Uses* section).

Elevated levels of polychlorinated biphenyls (PCBs) are found in Spokane River water, sediments, fish tissue, and effluents being discharged to the river. Ecology first documented PCB contamination in Spokane River fish in the early 1980s (Hopkins et al., 1985), and numerous investigations have evaluated the extent of the contamination (e.g., Ecology, 1995; Johnson, 1997; Johnson, 2001; Anchor, 2004). One location behind Upriver Dam required clean-up of PCBs in bottom sediments under the Model Toxics Control Act (MTCA, WAC 173-340). Cleanup was completed in January 2007, and long-term monitoring for PCBs at this site began in the fall of 2008.

Most of the Spokane River fish analyzed for PCBs fail to meet (exceeded) state surface water quality standards established to protect beneficial uses of surface waters, such as fish consumption. Fish consumption advisories have been issued for parts of the river (Spokane Regional Health District and Washington State Department of Health, 2003).

Fifteen waterbody segments of the Spokane River and Lake Spokane (also known as Long Lake, herein referred to as Lake Spokane) and one segment of the Little Spokane River are on the 2008 303(d) list for exceeding human health water quality criteria for PCBs (Table 1; www.ecy.wa.gov/programs/wq/303d/index.html).

Table 1. 303(d) Listings for Total PCBs in Spokane River Fish Tissue for 2008.

Waterbody	Reach	WB number	Watercourse Number	Listing ID
Spokane River	Idaho Border to Latah Creek	WA-57-1010	QZ45UE	Spokane River
	Latah Creek to Ninemile Dam	WA-54-1010		
Little Spokane River	Near mouth	WA-55-1010	JZ70CP	Little Spokane River
Lake Spokane (Long Lake)	Ninemile Dam to Lake Spokane Dam	WA-54-9040	QZ45UE	Lake Spokane (Long Lake)
Spokane River	Lake Spokane Dam to Mouth	WA-54-1020	QZ45UE	Spokane River

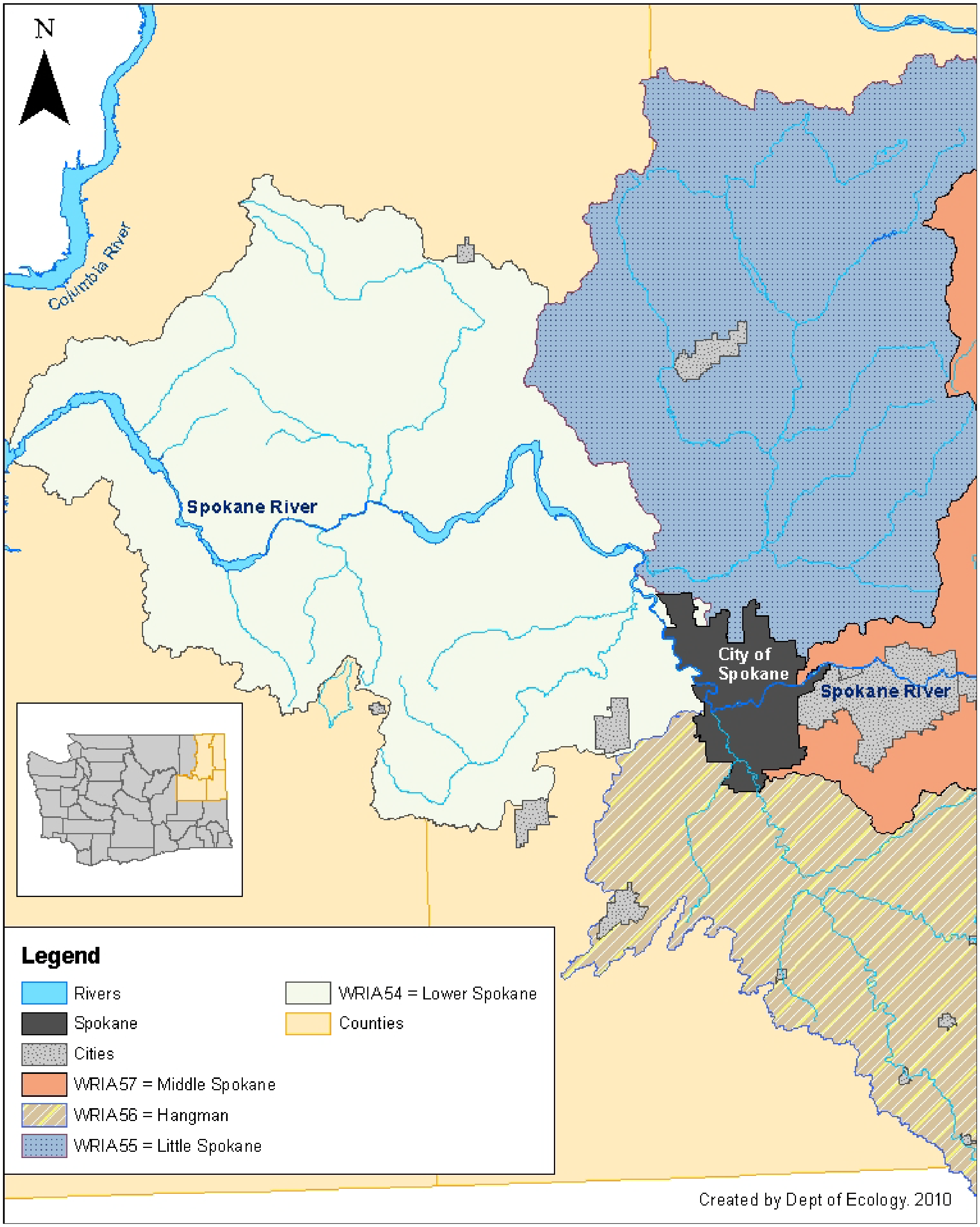

Figure 1. Location Map of Spokane River Showing Water Resource Inventory Areas.

The Spokane River and Lake Spokane have other water quality criteria exceedances that are not addressed in this source assessment. Table 2 shows the 303(d) listings for parameters other than PCBs that occur in the study area.

Table 2. Additional 303(d) Listings Not Addressed in this Report.

Waterbody	Parameter	Medium	Listing ID	Township	Range	Section
Spokane River	Temperature	Water	3737	25N	46E	06
	Total dissolved gas		15183	27N	39E	20
			15184	27N	39E	14
	Fecal coliform		16853	25N	42E	04
Lake Spokane (Long Lake)	Dioxin	Fish Tissue	42410	27N	41E	22
Spokane River			42411	26N	42E	20
			51586	26N	42E	28
			51587	25N	44E	03
Lake Spokane (Long Lake)	Dissolved oxygen	Water	40939	27N	40E	15
Spokane River			15188	26N	42E	17
			17523	25N	43E	02
			15187	25N	43E	18
			11400	25N	46E	06

The listings for dioxin in Spokane River and Lake Spokane fish are based on rainbow trout and mountain white fish collected by Ecology between 2001 and 2005 (Seiders et al., 2004, 2006, 2007). The listings are either for marginal exceedances of the human health criterion for 2,3,7,8-TCDD (dioxin) or for exceedances due to other polychlorinated dioxins and furans (PCDDs/PCDFs). These listings were not addressed in the present series of studies.

Ecology plans to address dioxin listings on a larger scale (possibly region- or state-wide) in the future. Because dioxins are often carried via air and can pollute sizeable areas not necessarily limited to watersheds, a larger TMDL footprint will likely be more effective and efficient at determining sources and subsequent evaluation of possible controls.

A TMDL for lead, cadmium, and zinc was completed for the Spokane River in 1999 (Pelletier and Merrill, 1998; Butkus and Merrill, 1999).

Water Quality Standards and Designated Uses

Applicable water quality criteria for PCBs to protect human health were promulgated by the U.S. Environmental Protection Agency (EPA) in the National Toxics Rule (NTR). The Washington State Water Quality Standards for Surface Waters (WAC 173-201A-240) contain aquatic life criteria for PCBs, and the Spokane Tribe of Indians' Surface Water Quality Standards (Resolution 2003-259) contain both human health and aquatic life-based PCB criteria. These regulations and other guidance are discussed separately below. The applicable numeric criteria are shown in Table 3.

Table 3. Water and Fish Tissue Criteria or Thresholds for Total PCBs [a] (pg/l: picograms per liter; parts per quadrillion; ng/g: nanograms per gram; parts per billion).

Regulation or Guidance	Aquatic Life - Water		Human Health [bc]		Fish Tissue Consumption Rate (kg/day)
	(chronic) (pg/l)	(acute) (pg/l)	Water (pg/l)	Tissue (ng/g)	
National Toxics Rule (40 CFR 131)	--	--	170	5.3	0.0065
Washington Water Quality Standards (Ch. 173-201A WAC)	1.4×10^{4} (d)	2×10^{6} (d)	--	--	--
Spokane Tribe Water Quality Standards (Resolution 2003-259)	1.4×10^{4} (e)	2×10^{6} (f)	3.37	0.1	0.0863
EPA National Recommended Water Quality Criteria (EPA, 2002)	--	--	64	2.0	0.0175
EPA Screening Value for Recreational Fishers (EPA, 2000a)	--	--	--	2.0	0.0175
EPA Screening Value for Subsistence Fishers (EPA, 2000a)	--	--	--	0.245	0.142

[a] total PCBs (sum of detected Aroclors, homologue groups, or congeners).
[b] based on a one-in-a-million (10^{-6}) excess lifetime cancer risk.
[c] for consumption of organisms and water.
[d] 24-hr average not to be exceeded.
[e] A one-hour average not to be exceeded more than once every three years on average.
[f] A four-day average not to be exceeded more than once every three years on average.

Regulations

National Toxics Rule

Criteria for the protection of human health were issued to the state in the NTR (40 CFR 130.36). Promulgated by EPA in 1992, and subsequently amended for PCBs in 1999, the NTR establishes numeric, chemical-specific water quality criteria for most priority pollutants. In fresh waters, human health criteria take into account the combined exposure of both drinking the water and eating fish and shellfish that live in the water. Criteria are calculated such that the upper-bound excess cancer risk is less than or equal to one in one million (10^{-6} risk level). Criteria for non-carcinogens are calculated such that effects should not be seen at exposures reflecting standard EPA exposure parameters (see equation below).

NTR human health criteria for PCBs (170 pg/l (parts per quadrillion) for a 10^{-6} risk level) were derived primarily to protect people from contaminated fish, the predominant exposure pathway. Exposure through water consumption is negligible, representing approximately 1% of the total PCB intake. The human health criteria are calculated using the following equation:

Equation 1. $$\boldsymbol{HHC} = \frac{\boldsymbol{RF} \times \boldsymbol{BW} \times (\mathbf{10^9}\ \boldsymbol{pg/mg})}{\boldsymbol{q1}^* \times [\boldsymbol{WC} + (\boldsymbol{FC}\ \boldsymbol{x}\ \boldsymbol{BCF})]}$$

Where:

- HHC = human health criteria.
- RF (risk factor) = the acceptable level of cancer risk. Washington's acceptable upper-bound excess cancer risk is one in a million (10^{-6}) for a lifetime exposure.
- BW (body weight) = the average body weight of the consumer. The NTR uses an average consumer body weight of 70 kg.
- q1* (cancer slope factor) = the cancer potency of each chemical. The NTR uses a q1* of 2 per mg/kg-day for PCBs.
- WC (water consumption) = the average daily consumption of water by a consumer. The NTR uses a water consumption rate of 2 L/day.
- FC (fish consumption) = the average fish tissue consumption by a consumer. The NTR uses a fish tissue consumption rate of 0.0065 kg/day.
- BCF (bioconcentration factor) = the concentration of a chemical in tissue accumulated through gill and skin divided by the concentration in the water column. The NTR uses a BCF of 31,200 L/kg for PCBs.

The water quality criterion can be converted to an equivalent fish tissue criterion using the BCF in Equation 2, where Cw is the concentration in water and Ct is the concentration in tissue:

Equation 2. $$\boldsymbol{BCF} = \frac{\boldsymbol{C_t}}{\boldsymbol{C_W}}$$

NTR-equivalent fish tissue concentrations may then be calculated by $C_t = BCF \times C_w$. The calculated NTR-equivalent concentration for PCBs in edible tissue (C_t) is 5.3 ng/g (parts per billion; Table 3).

The values used by EPA to derive the NTR human health criteria are not always used by public health agencies to establish fish consumption advisories in Washington and other NTR states. The Washington State Department of Health (WDOH), which has primary responsibility for assessing the need for fish consumption advisories, examines local information about higher fish consumption rates, and sub-populations at increased risk. Additionally, differences are present in the use of chemical toxicity factors and health effect endpoints. For example, water quality criteria for PCBs are based on protection against cancer, while state fish advisories for PCBs are based on protection against non-cancer effects.

Washington State

Water quality standards for surface waters of Washington State are contained in Chapter 173-201A of the Washington Administrative Code (WAC), last amended in 2006 and approved by EPA in 2008. The numeric criteria to protect aquatic life from PCB exposure is found in WAC 173-201A-240. The acute exposure criterion for PCBs in freshwater is 2×10^6 pg/l. The chronic exposure criterion is 1.4×10^4 pg/l (Table 3).

The standards also include a provision that "Toxic substances shall not be introduced above natural background levels in waters of the state which have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent on those waters, or adversely affect public health as determined by the department (WAC 173-201A-240(1)."

Designated uses (defined in WAC 173-201A-200(1)) in the Spokane River, from its mouth to the Idaho border include:

- Core summer habitat
- Spawning/rearing
- Recreation
- Water supply
- Harvesting
- Other miscellaneous uses

Spokane Tribe

The Spokane Tribe of Indians (Spokane Tribe) Surface Water Quality Standards (Resolution 2003-259) are similar to the Washington State Water Quality Standards in terms of narrative and numeric criteria. They apply to the westernmost part of the river defined by a line bisecting the Spokane Arm and Little Falls reservoir from river mile (RM) 32.5 to RM 0 (see Figure 2). The Tribal standards consider the Spokane River and most of its tributaries to be Class A surface water, with the exception of Blue Creek, Orazada Creek, and Sand Creek which are all Class AA tributaries to the Spokane Arm between RM 8 and RM 13. Designated uses for Spokane Tribe Class A and AA waters are similar to the Washington State standards, but also include primary contact (Washington waters are also designated for primary contact), ceremonial and spiritual, and cultural uses.

The Spokane Tribal narrative section for toxic pollutant standards is nearly identical to that of Washington State, including the adoption of a 10^{-6} risk level of for carcinogens. However, the Tribal numeric human health criteria are substantially lower (more restrictive) than those issued to Washington in the NTR (3.37 vs. 170 pg/l) due to different values used to derive the human health criteria. Tribal standards employ an aquatic organism consumption rate of 0.0863 kg/day, as opposed to the 0.0065 kg/day fish consumption rate in the NTR. In addition, the Spokane Tribe PCB criteria include an older cancer slope factor of 7.7 per mg/kg-d. Using the same approach used to derive an NTR-equivalent tissue value as described above in Eq. 2, the Spokane Tribe human health criteria of 3.37 pg/l translates to an equivalent edible tissue concentration of 0.1 ng/g.

Guidance

EPA Recommended National Water Quality Criteria

In 2002, EPA recommended new national water quality criteria including a new human health criterion for PCBs based on an upward revision of the fish consumption rate to 0.0175 kg/day (EPA, 2002). All other factors used to derive the recommended criterion (RF, BW, q1*, WC, and BCF) remained unchanged. The resulting recommended criterion for PCBs is 64 pg/l for water. The equivalent fish tissue concentration for this criterion is 2.0 ng/g (Table 3).

EPA Screening Values for Fish Advisories

Other threshold values which have no regulatory standing but are often used to assess potential public health risk are the EPA (2000a) tissue screening values (Table 3) used to evaluate fish advisories. Tissue screening values are derived in the same manner as NTR criteria and EPA's 2002 recommended national criteria, with adjustments only to the fish consumption rates. The screening value for recreational fishers is 2.0 ng/g, based on a consumption rate representing the 90^{th} percentile of sport fishers (0.0175 kg/day). The screening value for subsistence fishers (0.24 ng/g) is based on a 99^{th} percentile consumption rate (0.142 kg/day).

Watershed Description

Hydrology

The Spokane River begins in northern Idaho at the outlet of Coeur d'Alene Lake and flows west 112 miles to the Columbia River (Franklin D. Roosevelt Lake) (Figure 2). The watershed encompasses over 6,000 square miles (15,500 km^2) in Washington and Idaho. The river flows through the smaller cities of Post Falls and Coeur d'Alene in Idaho and large urban areas of the Spokane Valley and Spokane in Washington. Other cities in the basin include Liberty Lake, Deer Park, and Medical Lake Washington as well as Wallace and Kellogg Idaho upstream from Lake Coeur d'Alene.

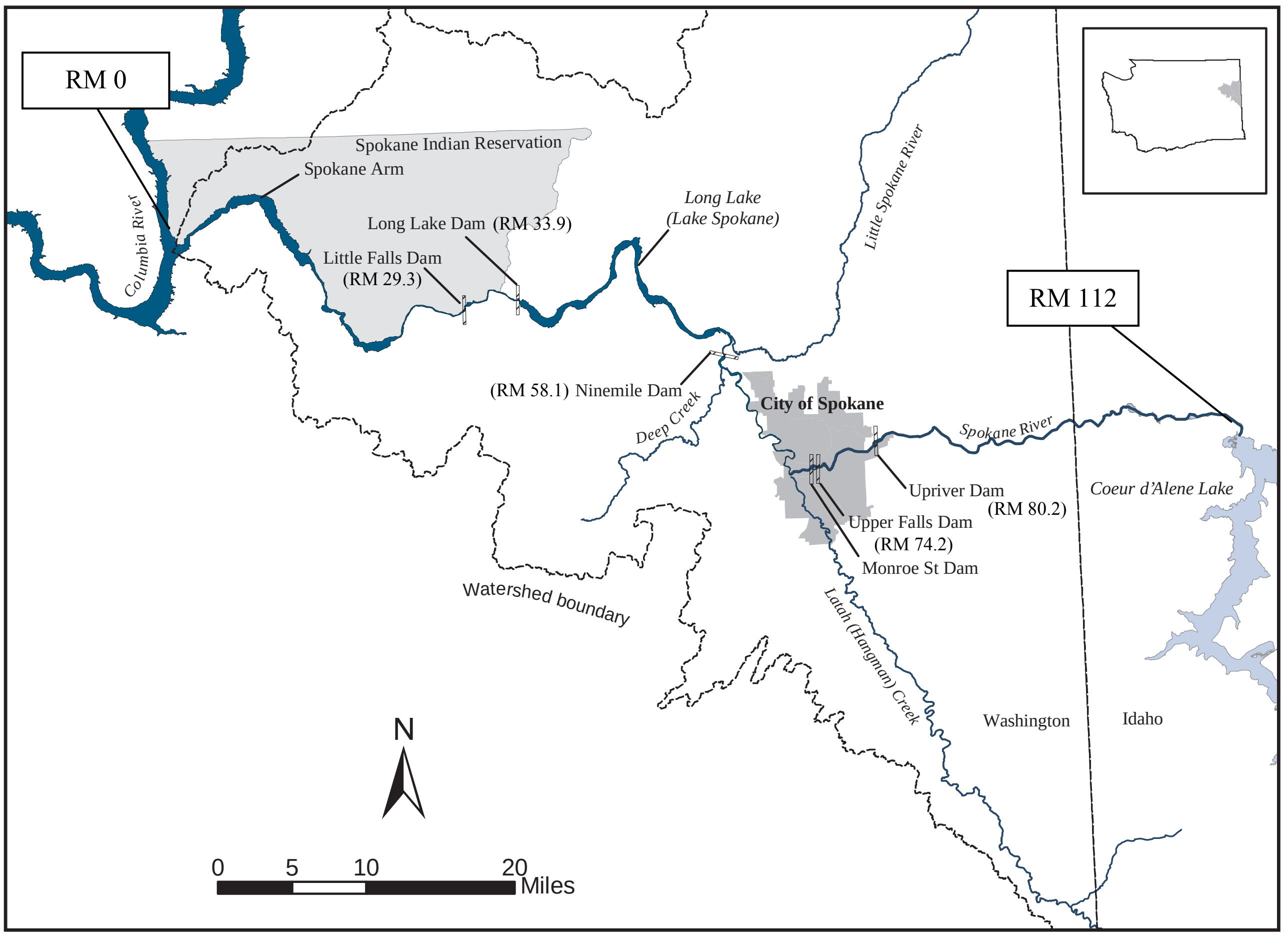

Figure 2. Spokane River Basin.

There are seven dams along the Spokane River:

1. Post Falls Dam (RM 100.8).
2. Upriver Dam (RM 80.2).
3. Upper Falls Dam (RM 74.5).
4. Monroe Street Dam (RM 74.0).
5. Ninemile Dam (RM 58.1).
6. Lake Spokane (Long Lake) Dam (RM 33.9).
7. Little Falls Dam (RM 29.3).

The dams create a series of pools which vary in length, the largest being 23-mile long Lake Spokane. Downstream from Lake Spokane, the Spokane River forms the southern boundary of the Spokane Tribe of Indians reservation from Chamokane Creek (RM 32.5) to the Columbia River at RM 639.0. The reservation occupies approximately 160,000 acres and is home to 2,441 tribal members (as of 2006).

The flow regime in the Spokane River is dictated largely by freezing temperatures in the winter followed by spring snowmelt. Figure 3 shows the harmonic mean flow at four points in the Spokane River. The harmonic mean is recommended by EPA (1991a) for use in assessing a river's loading capacity for long-term exposure to carcinogens such as PCBs. This is the appropriate measure of central tendency when dealing with rates, in this case rates of flow. Harmonic mean is discussed in more detail later in this report (see *Instream Loads*).

The annual mean flow for 1969-2002 was approximately 61,000 L/sec (2,154 cfs) where the Spokane River crosses the Idaho border. Flows increased to 82,000 L/sec (2,895 cfs) downstream of Spokane, reflecting the influx of groundwater through this river reach. Prior to 1969 there were un-quantified agricultural diversions for irrigation from the Spokane River in the vicinity of Post Falls.

Sediment

Downstream of Spokane the river corridor is largely undeveloped. The two major tributaries – Latah Creek (formerly Hangman Creek) and Little Spokane River – enter the Spokane River at RM 72.2 and RM 56.3, respectively. Latah Creek has an extremely flashy flow regime, responding rapidly to rainfall or snowmelt and is prone to erosion of its banks, thus delivering substantial sediment loads to the Spokane River (SCCD, 2002). In comparison, the Little Spokane River has an order of magnitude higher mean flow than Latah Creek, but carries slightly lower sediment loads.

One particular macro characteristic of the Spokane River is the general lack of fine depositional sediments in most of the river. Lake Coeur d'Alene acts as a settling basin for sediments transported in the upper watershed, and there are no tributaries to the river between the outlet of the lake and Latah Creek. Spokane River is essentially a free-stone stream environment. Although the dams break the river into a series of pools, there are few areas of placid water above Lake Spokane. The river velocities are high enough and the sediment load low enough to scour the bed or prevent settling of significant fine particulate matter, even immediately behind the dams. As a result, almost the entire riverbed upstream of Lake Spokane (the largest reservoir) is composed of gravel, cobble, and boulders with the finer sediment reserved for limited locations behind the dams, interstitial spaces within the river bed, isolated shoreline deposits, and certain fluvial bar features. One notable exception is the narrow band of fine, organic carbon rich sediments found near the Upriver Dam reservoir that constituted the MTCA cleanup site, previously mentioned.

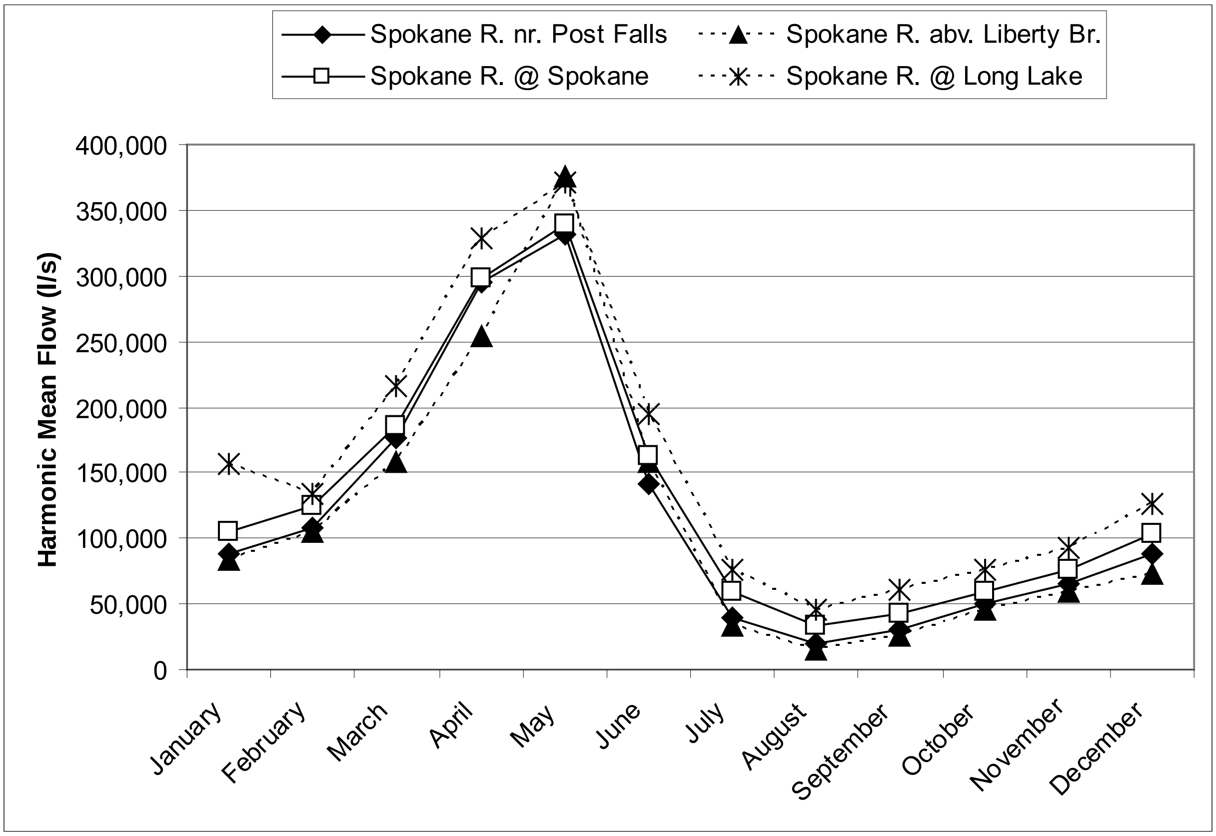

Figure 3. Spokane River Monthly Harmonic Mean Flows for Water Years 1969-2002.

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PCB Contamination of the Spokane River

Uses, Structure, and Analysis

PCBs were first produced for commercial use in 1929. Production continued until a 1979 ban on all PCB manufacturing, processing, and distribution due to evidence that PCBs build up in the environment and concerns about possible human carcinogenicity (Sittig, 1980). Principal uses were as heat transfer fluids, plasticizers, wax and pesticide extenders, lubricants, and fluids for hydraulic machinery, vacuum pumps, and compressors.

There are 209 individual forms of PCBs, known as congeners. The naming system for congeners is based on the number and location of chlorine atoms on the biphenyl rings (Figure 4).

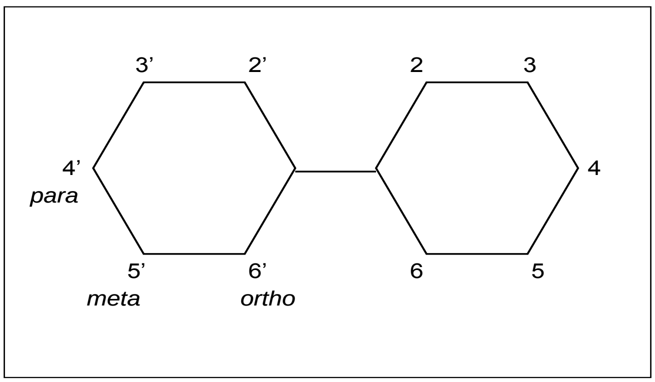

Figure 4. Generic PCB Molecular Structure and Numbering System.

In the U.S., PCBs were produced almost exclusively as Aroclors, the trade name for congener mixtures containing 21 to 68% chlorine by weight. The names given to the different Aroclors reflect this composition; Aroclor [PCB]-1248, for instance, contains approximately 48% chlorine by weight (12 refers to the number of carbon atoms in the biphenyl ring). Many different commercial Aroclor mixtures have been quantified as to their congener composition by Frame et al. (1996).

PCBs can be analyzed as individual congeners or Aroclor-equivalents. Congeners are usually analyzed by high-resolution gas chromatography/mass spectrometry (GC/MS) methods that are more costly, but more sensitive and thus give lower detection limits than the gas chromatography/electron capture (GC/ECD) method typically employed for Aroclor mixtures. Most of the historical fish tissue data for Washington State is from Aroclor analysis.

Much of the 600 million kg of PCBs used domestically has found its way into the environment through improper disposal or by leakage of sealed systems (Sittig, 1980). Loss to the environment through PCB use in open systems such as hydraulic fluids in die cast machinery, heat transfer systems, and specialty inks was also not uncommon (EPA, 2000a). Their primary uses are associated more with heavy industry or urban centers rather than agriculture (EPA, 1992). Direct application to the environment occurred on a lesser scale through use as pesticide extenders or oil mixtures applied to roads for dust control. Many of the same properties that made PCBs commercially desirable – their stability and resistance to degradation – make them extremely persistent in the environment. They have become one of the most ubiquitous of all environmental contaminants.

Environmental Fate

The persistence of PCBs increases with the degree of chlorination. Mono-, di- and tri-chlorinated biphenyls biodegrade relatively rapidly, tetrachlorinated biphenyls biodegrade slowly, and higher chlorinated biphenyls are resistant to biodegradation.

In soils, PCBs experience tight adsorption which generally increases with the degree of chlorination of the PCB. PCBs generally do not leach significantly in aqueous soil systems; the higher chlorinated congeners have a lower tendency to leach than the less chlorinated congeners. Vapor loss of PCBs from soil surfaces appears to be an important fate mechanism with the rate of volatilization decreasing with increasing chlorination.

In water, adsorption to sediment and suspended matter are important fate processes; PCB concentrations in sediment and suspended matter are typically much greater than in the water column. Although adsorption can immobilize PCBs (especially the higher chlorinated congeners) for relatively long periods of time, eventual re-solution into the water column has been shown to occur. The PCB composition in water will be enriched in the lower chlorinated PCBs because of their greater water solubility, and the least water soluble PCBs (highest chlorine content) will tend to remain adsorbed.

However, strong PCB adsorption to sediment significantly competes with volatilization, with the higher chlorinated PCBs having longer half-lives than the lower chlorinated PCBs. Lower chlorinated PCBs and ortho-substituted congeners are more volatile than the highly chlorinated PCBs. Henry's Law constants generally range from approximately 1 to 400 Pa m^3/mol (Pascals cubic meter/mole), indicating volatilization is an important transport process for PCBs in the environment. PCB volatilization from water, particularly at falls or dams, and from exposed contaminated soils can be an important transport process for PCBs and, in the absence of adsorption, PCBs volatilize relatively rapidly from water.

Losses of PCBs from the Great Lakes have been estimated by Eisenreich et al. (1992) as 66% via volatilization, 27% via sedimentation, and 7% through the outflow to other waterbodies. Dam spillways may cause significant transformations of an Aroclor mixture, with differential loss of constituent congeners (McLachlan et al., 1990). The dams along the Spokane River likely modify the dissolved and particulate fractions of PCBs as water moves downstream.

The combination of differential solubility, variable octanol-water partitioning coefficients (K_{ow}), and volatilization leads to weathering of Aroclor mixtures. In environmental samples, these physical and chemical processes change the composition of released PCB mixtures over time. Thus, sediment and water samples rarely have congener patterns which match a commercial Aroclor due to weathering. If released to the atmosphere, PCBs will primarily exist in the vapor-phase; the tendency to become associated with the particulate-phase will increase as the degree of chlorination increases. Physical removal of PCBs from the atmosphere is accomplished by wet and dry deposition.

PCBs accumulate in the lipids (fats) of fish and other animals. Lipid solubility increases with the degree of chlorination (Mabey et al., 1982), reflected in their high K_{ow}. The range of log K_{ow} is from approximately 4.6 for monochlorinated congeners to 8.2 for decachlorobiphenyl. Peak bioaccumulation occurs between log K_{ow} 6.5 and 7.0 (Fisk et al., 1998), those congeners with 5 or 6 chlorines. It is believed that congeners with log $K_{ow} > 7.0$ are too large to be efficiently assimilated in the fish digestive tract.

All known aerobic and anaerobic biotic processes act to de-chlorinate PCBs (ATSDR, 1997). Substitution of either a hydrogen or chlorine atom is generally required by an organism to excrete a PCB molecule. Congeners which do not have chlorines in meta positions can be metabolized and excreted. Organisms preferentially metabolize and excrete different PCB congeners depending on their resistance to substitution. Substitution is generally more difficult for the richly chlorinated congeners, leading to preferential bioaccumulation of heavier, but not the heaviest, congeners.

Historical Data on PCBs in the Spokane River

Ecology has analyzed PCBs in a variety of water, sediment, and fish tissue samples collected from the Spokane River over the past two decades. Additional data have been collected by or in cooperation with the U.S. Geological Survey (USGS) and various NPDES dischargers. More recent work has focused attention on characterizing PCB contaminated sediments behind Upriver Dam. The various data collection efforts going back to 1980 are listed in Table 4.

PCBs were first analyzed in the Spokane River during Ecology statewide screening-level surveys of contaminants in fish from rivers and lakes (Hopkins et al., 1985; Hopkins, 1991; Serdar et al., 1994). Spokane River fish almost always had high PCB concentrations. For instance, total PCBs in whole fish ranged up to 2,300 ng/g (parts per billion) in northern pikeminnow (*Ptychocheilus oregonensis*) collected in 1983. Fillets from mountain whitefish (*Prosopium williamsoni*) and bridgelip sucker (*Catostomus columbianus*) from Riverside State Park in the City of Spokane were also elevated with total PCB concentrations of 230 and 370 ng/g, respectively. Largescale suckers (*Catostomus macrocheilus*) sampled from Lake Spokane had a whole body concentration of 720 ng/g.

In 1993, Ecology expanded its investigation of PCBs in the Spokane River by analyzing multiple fish species and sediments at reaches encompassing the entire river. Johnson et al. (1994) confirmed the high PCB levels seen earlier and found the highest fish tissue and sediment levels in the reach above Upriver Dam (up to 2,800 ng/g in whole largescale suckers and 3,200 ng/g in sediments) with levels gradually declining downstream.

Table 4. Summary of PCB Data Collected on the Spokane River, 1980-2007.

Investigator	Sample Type	Year Collected	Purpose
Ecology (Hopkins et al., 1985)	Fish tissue	1980-1983	Statewide survey of contaminants in rivers
Ecology (Hopkins, 1991)	Sediment	1989	Statewide survey of contaminants in rivers
Ecology (Serdar et al., 1994)	Fish tissue[1,2] Sediment	1992	Statewide survey of contaminants in lakes
Ecology (Johnson, et al., 1994)	Tissue Sediment	1993	Survey for PCBs in the Spokane River
Ecology (Davis et al., 1995)	Fish tissue		Statewide survey of pesticides and PCBs
Ecology (Ecology, 1995)	Fish and crayfish, tissue, sediment, surface water, effluent, sludge	1994	Synoptic survey of PCBs in the Spokane River
Hart Crowser, 1995	Effluent		Sampled Kaiser Trentwood effluent coincidental with Ecology sampling
Ecology (Huntamer, 1995)	Sediment		Microscopic examination and PCB analysis of sediments behind Upriver Dam
Ecology (Golding, 1996)	Effluent Sludge	1995	Follow-up to effluent and sludge sampling conducted during 1994 synoptic survey
Ecology (Johnson, 1997)	Fish tissue	1996	Survey to determine PCB levels in Spokane River fish
Ecology and USGS (Johnson, 2000)	Fish and crayfish tissue	1999	Survey to determine PCB levels in Spokane River fish
Ecology (Johnson and Norton, 2001)	Sediment	2000	Chemistry and bioassays of Spokane River
Ecology (Golding, 2001)	Surface water Effluent		Survey of PCBs in Kaiser Trentwood effluents and receiving waters
Ecology (Golding, 2002)	Effluent	2001	Survey of PCBs in industrial and WWTP effluents
Ecology (Jack and Roose, 2002)	Fish tissue		Intensive survey of PCBs in Lake Spokane fish
Exponent and Anchor, 2001	Sediment		Survey of PCBs in sediments behind Upriver Dam
SAIC, 2003a	Effluent Sludge	2002	Survey of PCBs in effluent and sludge from Inland Empire
SAIC, 2003b	Fish tissue		Intensive survey of PCBs in Lake Coeur d'Alene fish
Anchor Environmental (Anchor, 2004)	Surface water Groundwater	2003	Remedial investigation of PCBs in the vicinity of Upriver Dam MTCA site
Merill and Bala, 2004	Effluent	2002-2003	Bi-weekly monitoring of PCBs in Kaiser Trentwood effluent
Kaiser (Kaiser, 2005)	Effluent	2004-2005	PCBs in Kaiser Trentwood effluent
Merill and Bala, 2004	Effluent	2002-2003	Bi-weekly monitoring of PCBs in Kaiser Trentwood effluent
Ecology (Serdar and Johnson, 2006)	Fish tissue	2005	Synoptic survey of PCBs in Spokane River fish
Ecology (Seiders, Deligeannis, and Kinney, 2006)	Surface water Fish tissue		Statewide survey of toxic contaminants in waters and fish, including Spokane River
Parsons, 2007	Stormwater	2007	Survey of PCBs in Spokane stormwater

WWTP: wastewater treatment plant.

In 1994, Ecology further increased the number of organisms and locations analyzed for PCBs in the Spokane River. Results again confirmed the pattern of contamination among sites seen in 1993. The 1994 study also found that Little Spokane River fish had higher than expected PCB levels. Crayfish had low accumulations of PCBs.

The 1994 samples also included bottom sediments and potential industrial/municipal sources of PCBs to the river. This helped define the extent of contamination behind Upriver Dam, largely by delineating the area of depositional material. Nearly the entire river was surveyed for the presence of significant bulk fine sediment deposits between the state line and Lake Spokane, but the "hot spot" behind Upriver Dam was the only sediment deposit found during that study.

Perhaps the most important findings from 1994 were the characterizations of PCB sources to the river. Sewage treatment plants, industrial facilities, and industrial sites along the river were sampled to assess their relative contribution of PCBs. Results showed that sources upstream of the Idaho border were negligible, but downstream there was a substantial ongoing PCB source at the Kaiser Trentwood aluminum plant, potentially significant sources such as the Liberty Lake wastewater treatment plant (WWTP) and the former Inland Metals site, and a historically large source from the Spokane Industrial Park, which now discharged to the Spokane WWTP. Low PCB concentrations were found at a Washington Water Power yard, located just above the river bank, ruling this site out as a potentially significant source. PCB discharges from industrial and municipal treatment plants are discussed in more detail later in this section of the report.

Ecology analyzed more fish in 1996, specifically to determine if the trend toward decreasing PCB concentrations continued. The three species used most often for comparisons in the Spokane River – rainbow trout, mountain whitefish, and largescale suckers – all showed substantial decreases in PCB concentrations from earlier data (Table 5). However, PCB levels continued to remain high relative to other areas in the state.

Since 1999, surveys in the Spokane River have verified previous data or further characterized the contamination so that its implications are better understood. The three major areas where study efforts have concentrated in the past decade are:

- Continued sampling of fish to evaluate temporal trends and conduct human health risk assessment.
- Continued monitoring of known PCB sources.
- Characterization of the Upriver Dam cleanup site.

In July 1999, USGS collaborated with Ecology to further document PCB contamination in fish from the mainstem of the Spokane River (USGS, 1999; Johnson, 2000). This study found that whole largescale suckers exceeded a criterion of 110 ng/g used to protect fish-eating wildlife (Newell et al., 1987). Concentrations in whole suckers ranged from 120 to 700 ng/g total PCBs. For mountain whitefish and rainbow trout (*Oncorhynchus mykiss*), fillets and whole fish were analyzed. Peak concentrations were found in rainbow trout in the vicinity of RM 85 (Plante Ferry) and in mountain whitefish in the vicinity of RM 63 (Ninemile). Maximum concentrations were about 1,600 ng/g for both species.

Table 5. Summary of Total PCB Concentrations in Fish Tissue from the Spokane River (mean concentrations in ng/g, ww).

Location and Tissue Type	Total PCB Concentrations Measured by:					
	Aroclor Analysis					Congener Analysis
	1993[a]	1994[b]	1996[c]	1999[d]	2001[e]	2005[f]
Rainbow trout - fillet						
State line	--	--	--	106	--	55
Plante Ferry	918	424	799	891	--	153
Above Monroe Dam*	--	145	76	226	--	73
Ninemile	490	371	76	143	--	
Mountain whitefish - fillet						
Above Monroe Dam	--	568	381	339	--	234
Ninemile	522	139	444	632	--	139
Little Spokane	--	222	145	--	--	--
Upper Lake Spokane	--		--	--	73	43
Lower Lake Spokane	780	113	--	--	--	76
Largescale suckers - whole						
State line	--	--	--	120	--	56
Plante Ferry	2,005	531	530	283	--	122
Above Monroe Dam	--	201	116	445	--	1,823
Ninemile	1,210		345	680	--	--
Little Spokane	--	440	366	--	--	--
Upper Lake Spokane	--	--	--	--	265	327
Lower Lake Spokane	410	820	--	--	357	254

--no data
[a] Johnson et al., 1994
[b] Ecology, 1995
[c] Johnson, 1997
[d] Johnson, 2000
[e] Jack and Roose, 2002
[f] Serdar and Johnson, 2006
*Same reach as Mission Park

In 2001, Ecology, WDOH, and the Washington Department of Fish and Wildlife (WDFW) collaborated in the collection of five species to evaluate PCB concentrations in Lake Spokane fish tissues (Jack and Roose, 2002). In general, largescale suckers and mountain whitefish had the highest PCB concentrations. Total PCBs in whole suckers ranged from 160 to 340 ng/g, while mountain whitefish fillets ranged from 60 to 89 ng/g. The greater uptake and retention of PCBs in suckers is likely influenced by their relatively high lipid content, benthic (bottom feeding) habits, limited capabilities for PCB excretion, and longevity. Largescale suckers analyzed from Lake Spokane were up to 24 years old (Jack and Roose, 2002). Fish consumption advisories were issued in 2003 and are further discussed below.

In 2005, another intensive study was conducted to expand and update the information on chemical contaminants in Spokane River fish (Serdar and Johnson, 2006). Fish from six locations between the Washington/Idaho state line and lower Lake Spokane were collected. Samples of fillets and whole fish were analyzed for PCBs, polybrominated diphenyl ether flame retardants (PBDEs), arsenic, cadmium, lead, and zinc. A subset of samples was also analyzed for polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans (PCDD/PCDFs).

Compared to historical levels, PCB concentrations appeared to have decreased in all parts of the Spokane River except the Mission Park reach. Relative to other parts of the state, Spokane River fish were within the mean and median for fillet PCB concentrations. However, whole fish results for Mission Park and Lake Spokane were at or above the upper end of the range of whole fish statewide.

Spokane River fish also substantially exceeded statewide comparisons for concentrations of PBDEs, zinc, lead, and cadmium (whole fish samples only). The Urban Waters Program at Ecology is currently pursuing sources of PBDEs to the river. Metals contamination of the Spokane River is from historic mining in Idaho's Silver Valley and has been the subject of many past studies. As previously mentioned, a TMDL has been established for lead, cadmium, and zinc in the Spokane River.

Ecology's Washington State Toxics Monitoring Program also sampled fish from the Spokane River in 2003-04 for a suite of toxic compounds. PCBs were not analyzed due to concurrent intensive PCBs surveys on the river. A recommendation from this effort was to list the Spokane River as impaired on the 303(d) list for 2,3,7,8-TCDD (dioxin) (Seiders et al., 2006).

Table 5 provides a comparison of the total PCB concentrations from the various Ecology studies.

Fish Consumption Advisories

Based on the elevated PCB and lead levels in Spokane River fish, WDOH and the Spokane Regional Health District issued an advisory in 2003 to avoid or limit consumption of fish in parts of the Spokane River (www.doh.wa.gov/ehp/oehas/fish/consumpadvice.htm#Spokane%20River). The health departments later concluded that the advisory would also be protective for PBDEs. The advisory, updated in April 2008 based on fish tissue samples collected for the present 2003-07 study, is summarized in Table 6.

Table 6. April 2008 Spokane River Fish Consumption Advisories.

Location	Species	Consumption Advice
Spokane River – All Areas	All Species	Do not eat the fish head or entrails.
Idaho Border to Upriver Dam	All Species	Do not eat
Upriver Dam to Ninemile Dam	Largescale Sucker	Do not eat
	All Other Species	One meal per month
Lake Spokane (Long Lake)	Largescale Sucker	One meal per month
	Brown Trout	
	Largemouth Bass	Two meals per month
	Smallmouth Bass	
	Rainbow Trout	Two meals per week
	Yellow Perch	

National Pollutant Discharge Elimination System (NPDES) Permits

Ecology has issued NPDES wastewater discharge permits to a variety of industrial and municipal facilities in the Spokane River basin. Some of these facilities have discharged PCBs in the past. Ecology-directed MTCA sediment cleanup actions upstream of Upriver Dam identified the Kaiser Trentwood facility and the Spokane Industrial Park as the most prominent historic sources of PCB releases in that portion of the river. Recent studies have confirmed the presence of PCBs in the waste streams of some permitted Spokane River dischargers. Appendix A lists the permitted discharges to the greater Spokane watershed by WRIA and permit number.

The NPDES permits in Appendix A are coded based on the type of discharge to waters of the state. Those permit numbers beginning with ST are for the discharge of municipal and industrial effluents to ground or industrial effluents to municipal sewer systems. The City of Spokane WWTP receives effluent from a number of these industrial dischargers. Permit numbers beginning with WAG are general NPDES permits. "WA" permits are those allowing discharge of effluents to surface waters.

In addition to the industrial and municipal discharges in Appendix A, the City of Spokane has a partially combined sewer-stormwater system. Spokane is permitted for stormwater discharges under the NPDES Phase II program. A combined sewer is a conjoined system of (1) stormwater collection from areas such as roofs and parking lots and (2) raw sewage. During heavy rain or snowmelt events, the influx of stormwater to the combined system may overwhelm its carrying capacity. At that time, a combined sewer overflow (CSO) event occurs, and a portion of the stormwater-sewage mixture bypasses the local WWTP and discharges directly to the river.

There are a total of 24 CSO points within the City of Spokane (City of Spokane, 2002). These sewers may discharge during high-flow periods or inadvertently during maintenance activities. Because of the variety of previous uses of PCBs, they may be discharged to the river during these overflow events. Some of the stormwater is delivered directly to the river through storm sewers and into ground via drywells or infiltration basins.

Historic NPDES Effluent PCB Concentrations

Some of the NPDES-permitted effluents discharged to the Spokane River have been sampled for PCBs by Ecology and others (Table 7). Ecology (1995), Golding (1996, 2001, 2002), and SAIC (2003a) report effluent data from July 1994 through June 2002 (Table 7). These samples were analyzed by both Aroclor-equivalents and congener-specific methods. While the methods may not be directly comparable to each other, these data are included to illustrate the range of loads and potential variability from these sources.

Historic PCB loads from the Kaiser Trentwood aluminum mill were consistently higher than other facilities by about an order of magnitude, although loads appear to have declined from 1994 to 2001. Kaiser also monitored PCBs in their outfall bi-weekly in 2002 and 2003 (Merrill and Bala, 2004). The median concentration of total PCBs in 2002 was 2,700 pg/l (140 mg/day), decreasing to 1,200 pg/l (90 mg/day) in 2003.

PCB concentrations in Kaiser effluent during 2002-2003 were generally consistent, with variability expressed by peaks – an order of magnitude increase from normal levels – occurring at two to five month intervals. The monitoring result for 4/9/2002 showed an unusually high PCB level in the effluent, 2.2×10^6 pg/l (0.125 kg/day), which persisted for a maximum of three weeks before returning to typical levels. PCB levels jumped again in November 2002 when four consecutive monitoring events from 11/18/2002 to 12/29/2002 found effluent concentrations of 2.6×10^7 pg/l, 3.2×10^6 pg/l, 4.8×10^7 pg/l, and 3.4×10^6 pg/l. Assuming an average daily load of 0.99 kg/day for a period of six weeks (one week prior to discovery until one week following the last elevated measurement), approximately 53 kg total PCB was delivered to the Spokane River from the Kaiser facility during this period.

Table 7. Summary of Spokane Area PCB Point Source Data.

Source	Date	Method	Total PCBs (pg/l)	Identified Aroclor	Effluent Flow (ML/day)	PCB Load to River (mg/Day)
Kaiser Trentwood	08/1/94 [a]	Aroclor	21,000	PCB-1248	109	2,290
	12/5/95 [b]		29,000		67.8	1,970
			34,000			2,300
	12/6/95 [b]		25,000		68.5	1,710
			29,000			1,990
	08/14/00 [c]		53,000		96.1	5,100
			900 U	NA	96.1	0
	08/15/00 [c]		900 U			0
			25,000	PCB-1248		2,400
	05/1/01 [d]		10,174 NJ	NA	62.1	630
	05/2/01 [d]		5,165 NJ			320
Spokane WWTP	05/1/01 [d]	congener	1,813 NJ	NA	142	260
	05/2/01 [d]		1,767 NJ			250
Liberty Lake WWTP	05/1/01 [d]	congener	1,917 NJ	NA	2.46	4.7
	05/2/01 [d]		1,543 NJ			3.8
Inland Empire Paper	05/1/01 [d]	congener	2,436 NJ	NA	16.3	40
	06/5/02–a.m. [e]		5,484		20.0	110
	06/5/02–p.m. [e]		4,305		18.0	78
Spokane Industrial Park	07/31/94 [a]	Aroclor	9,000 U	NA	*	*
	08/4/94 [a]		31,000 U			
	05/1/01 [d]	congener	9,371 NJ			
	05/2/01 [d]		7,108 NJ			

Bold: Analyte detected
NJ: There is evidence that the analyte is present. Associated numerical result is an estimate.
U: Analyte not detected at or above the reported value.
NA: not applicable
ML/day: 0.264 MGD (million gallons per day)
* Currently discharges to Spokane WWTP; formerly discharged to Spokane River.
[a] Ecology, 1995
[b] Golding, 1996
[c] Golding, 2001
[d] Golding, 2002
[e] SAIC, 2003a

PCB levels in effluent samples collected from the Spokane WWTP, Liberty Lake WWTP, and Inland Empire Paper in 2001-2002 ranged from 1,543 to 5,484 pg/l. Higher concentrations of 7,108 and 9,371 pg/l were reported in effluent from the Spokane Industrial Park analyzed in 1994. This facility now discharges to the Spokane WWTP.

PCBs Behind Upriver Dam, 1995-2004

As mentioned previously, bulk fine sediment deposits are sparse in the Spokane River upstream of Lake Spokane, with the exception of scattered shoreline, bar feature, and lower energy zones. Two notable exceptions are the narrow bands of silt and organically-enriched sediments deposited behind Upriver Dam (Figure 5).

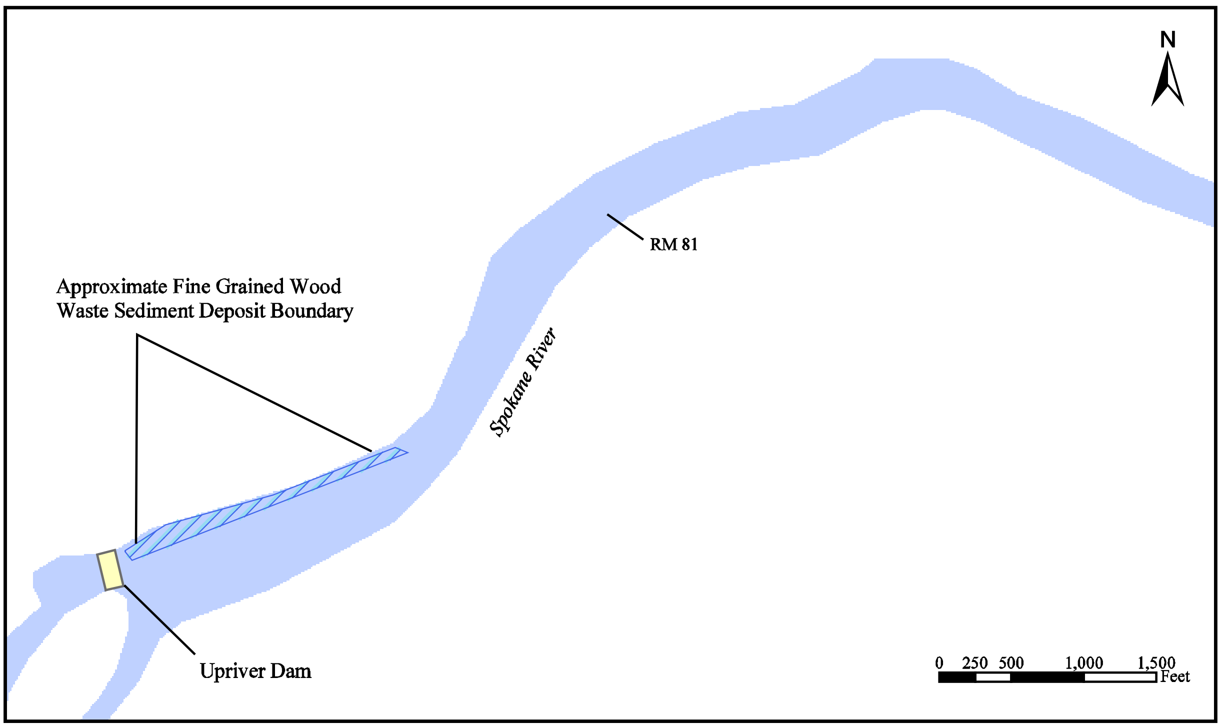

Figure 5. Location of Fine-Grained Wood Waste Sediment Deposit Behind Upriver Dam.

Following discovery of PCB contamination behind Upriver Dam in 1993 and confirmation of high PCB levels in 1994, subsequent sampling consisted mainly of defining the boundary of contamination and distribution of fine sediments upstream of the dam. Sediments within a band located immediately behind the dam generally showed PCBs at 1,000-5,000 ng/g dry weight (dw) and in some samples contained >10% total organic carbon, gradually becoming sandier at the margins (Ecology, 1995; Johnson and Norton, 2001). Huntamer (1995) conducted a microscopic analysis of the organic-enriched sediments and found them to be largely composed of wood particles, consistent with un-aided visual observation made earlier. Huntamer also observed charcoal which he speculated may have originated from recent wildfires in the area.

In February 2003, Ecology entered into a Consent Decree with Kaiser and Avista (formerly Washington Water Power) to evaluate site conditions at Upriver Dam. The remedial investigation (RI) and feasibility study (FS) (Anchor 2005a and 2005b) required under the Consent Decree informed decisions that led to the completion of a cleanup under MTCA. Aside from sediment characterization, the RI/FS addressed other components of the aquatic ecosystem associated with the Upriver Dam contamination, such as sampling PCBs in the water column and in hydraulically-connected groundwater wells, as well as bathymetric surveys of the reach.

Groundwater monitoring in the area indicates there is localized loss of surface water to the aquifer due to the hydraulic difference between the reservoir pool and the river surface downstream of the dam. Monitoring wells located downgradient of the dam showed low PCB concentrations (9-116 pg/l), which were in the range of associated field and laboratory blanks (10-226 pg/l), suggesting the presence of PCBs was due to sampling or lab contamination rather than PCB movement from the reservoir to groundwater (Anchor, 2004).

Surface water sampling was conducted both upstream and downstream of the Upriver Dam site as part of the RI/FS. During the RI/FS, upstream surface water samples and surface water samples collected at the Upriver Dam site (120 and 110 pg/l respectively) exceeded the EPA National Recommended Water Quality Criterion of 64 pg/l. As being an applicable, relevant, and appropriate requirement (ARAR) under MTCA, the 64 pg/l criterion was selected as the surface water criterion at the Upriver Dam site.

Numerous sediment samples were analyzed in and around the known area of contamination as part of the RI/FS. Samples were also collected upstream in backwaters identified as potential depositional areas. Results identified a second significant fine sediment deposit above Upriver Dam at RM 83.4 (Donkey Island) and corroborated earlier findings that deposited fine material and elevated PCB concentrations are absent outside the known areas of bulk fine sediment accumulation.

The Cleanup Action Plan by Ecology (2005) identified a sediment cleanup value of 62 µg/kg total PCBs as protective of human health and the river ecological community. The 62 µg/kg PCB sediment cleanup value was derived for the protection of aquatic life inhabiting the upper layer (0 - 10 cm) of the sediment. The selected sediment cleanup level is based on the lowest apparent effects threshold (AET) suggested for use in freshwater sediments (Michelson, 2003).

The Upriver Dam cleanup was completed in January 2007. A sediment cap was placed over the primary contaminated area on the river bed behind Upriver Dam (Deposit 1) using an excavator on a floating barge. A second smaller area of contaminated sediment was excavated in the Donkey Island area just east of Argonne Road (Deposit 2). The sediment cap that was placed at Deposit 1 was required to be 13 inches in depth. Of the 13 inches, 4 inches were bituminous coal, followed by 6 inches of clean sand, and then armored with 3 inches of gravel. The total size of the cap at Deposit 1 encompassed approximately 3.5 acres. Deposit 2 covered approximately 0.2 acres of contaminated sediment that was excavated as part of the remedial action. The estimated amount of contaminated sediment that was excavated at Deposit 2 is 600 cubic yards.

The first scheduled monitoring event at Deposit 1 to check the integrity of the sediment cap and sample the sediments for PCBs began in the fall of 2008. The results of the 2008 monitoring event found that the cap was fully intact with an additional 1 to 2 feet of deposited sand and woody material on top of the cap. The additional material is suspected to be as a result of the high spring-runoff flows that occurred in 2008. The core samples that were taken of the cap and the grab samples of the newly deposited sand did not detect PCBs higher than the cleanup value.

2003-2007 PCB Source Assessment

Goals

Sampling for the Spokane River PCB source assessment study was initially conducted by the Ecology Environmental Assessment Program from September 2003-July 2004. Additional fish and stormwater samples were collected in late 2005 and early 2007, respectively. The overall goal of this effort was to quantify PCB contamination and identify necessary reductions in sources and the receiving waters to meet applicable PCB water quality criteria for the Spokane River.

Objectives

Specific objectives of the study were to:

1. Obtain representative data on PCB concentrations and ancillary parameters in the Spokane River water column, NPDES permitted discharges, bottom sediments, and fish tissue.
2. Assess trends and natural recovery rates for PCBs in Spokane River sediments.
3. Determine the Spokane River's loading capacity for PCBs.
4. Evaluate a food web bioaccumulation model to predict PCB concentrations in Spokane River fish.

The first objective was addressed by sampling PCBs in industrial and municipal effluent, surface water, suspended particulate matter, stormwater, surface and sub-surface sediments, and fish tissue.

The second objective was achieved by analyzing PCBs in sediment cores.

Water column PCB measurements from semi-permeable membrane devices, a passive sampling technique, were used to assess the loading capacity of the Spokane River. Estimates of the PCB load reductions needed to meet the more stringent human health criteria of the Spokane Tribe were based on loading capacity and on current estimates of PCB discharges in effluent and stormwater.

The Arnot-Gobas food web bioaccumulation model (Arnot and Gobas, 2004) was employed to estimate site-specific critical PCB concentrations in water and sediment. Needed load reductions to meet water quality criteria were then estimated using PCB loading capacities derived from the model.

Field Data Collection

Sampling Locations

Sampling station locations for the source assessment study are shown in Figures 6-10. Coordinates and a description of each station location are in Appendix B.

For the purpose of this report, "Stations" are identical to the "User Location ID" in Ecology's Environmental Information Management (EIM) database (available on the internet at www.ecy.wa.gov/eim/). All of the data for this project are available through EIM under the User Study ID named "DSER0010", with two exceptions:

1) The Ninemile rainbow trout fillet data are under the User Location ID "Spokane-F" or the User Study ID "WSTMP03T".

2) The 2007 stormwater data from the Parsons, (2007) study were entered into EIM under the User Study ID "brwa0004".

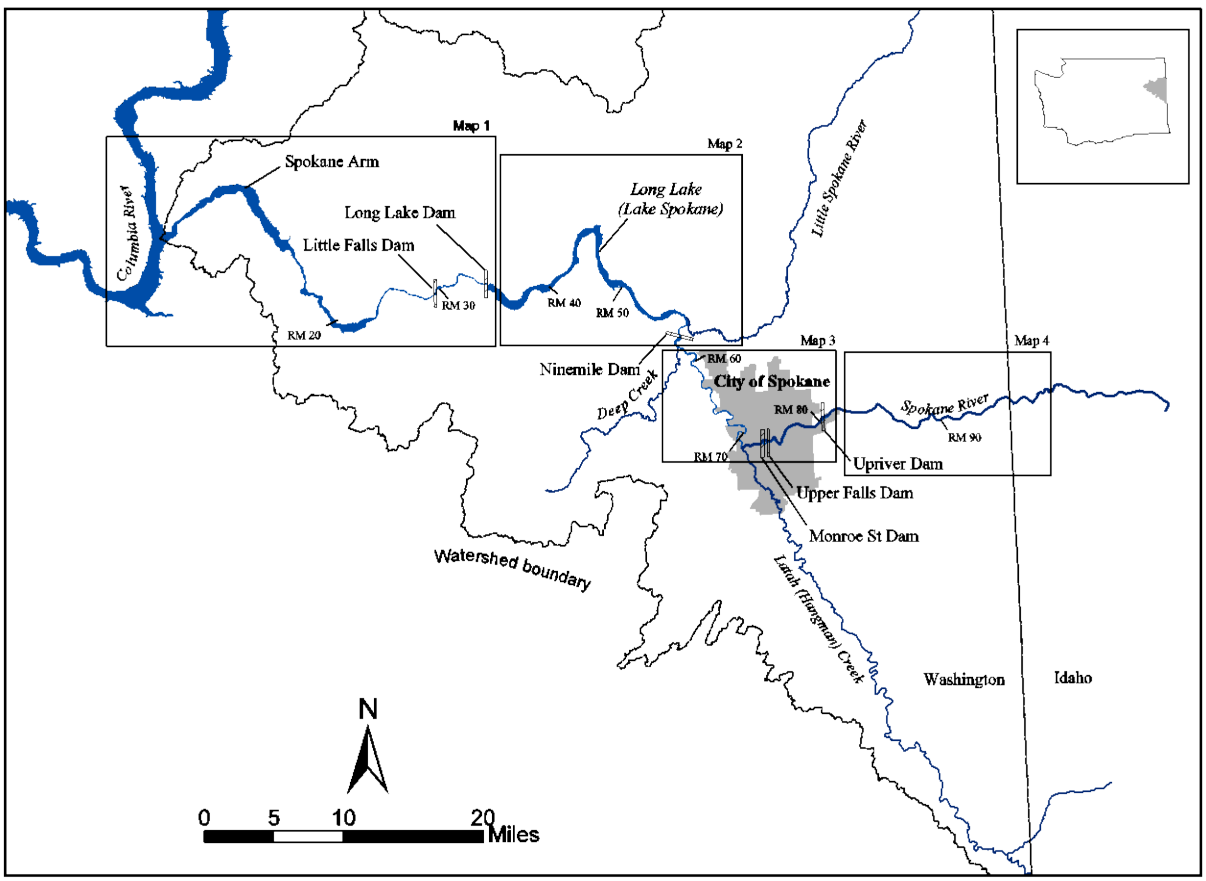

Figure 6. Sampling Maps for Spokane River PCB Source Assessment Study.

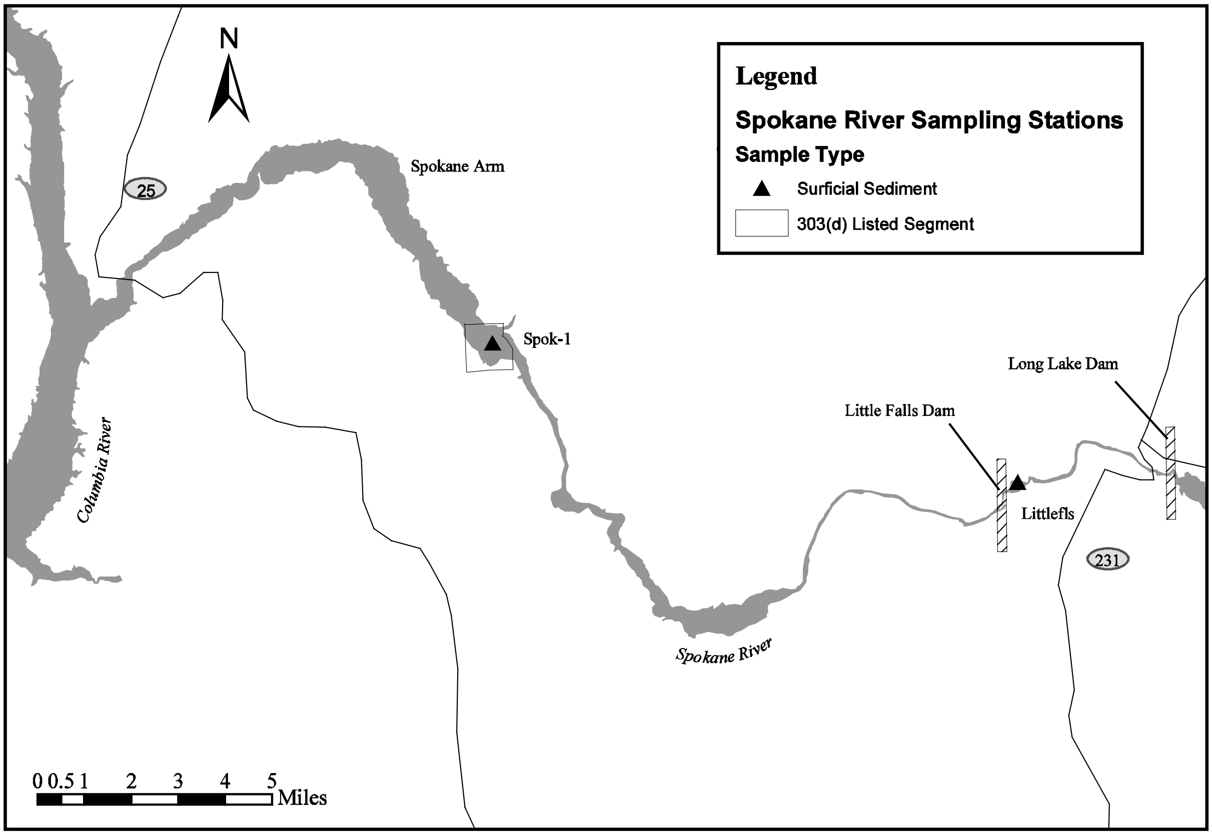

Figure 7. Sampling Map 1: Spokane River Mouth to Long Lake (Lake Spokane) Dam.

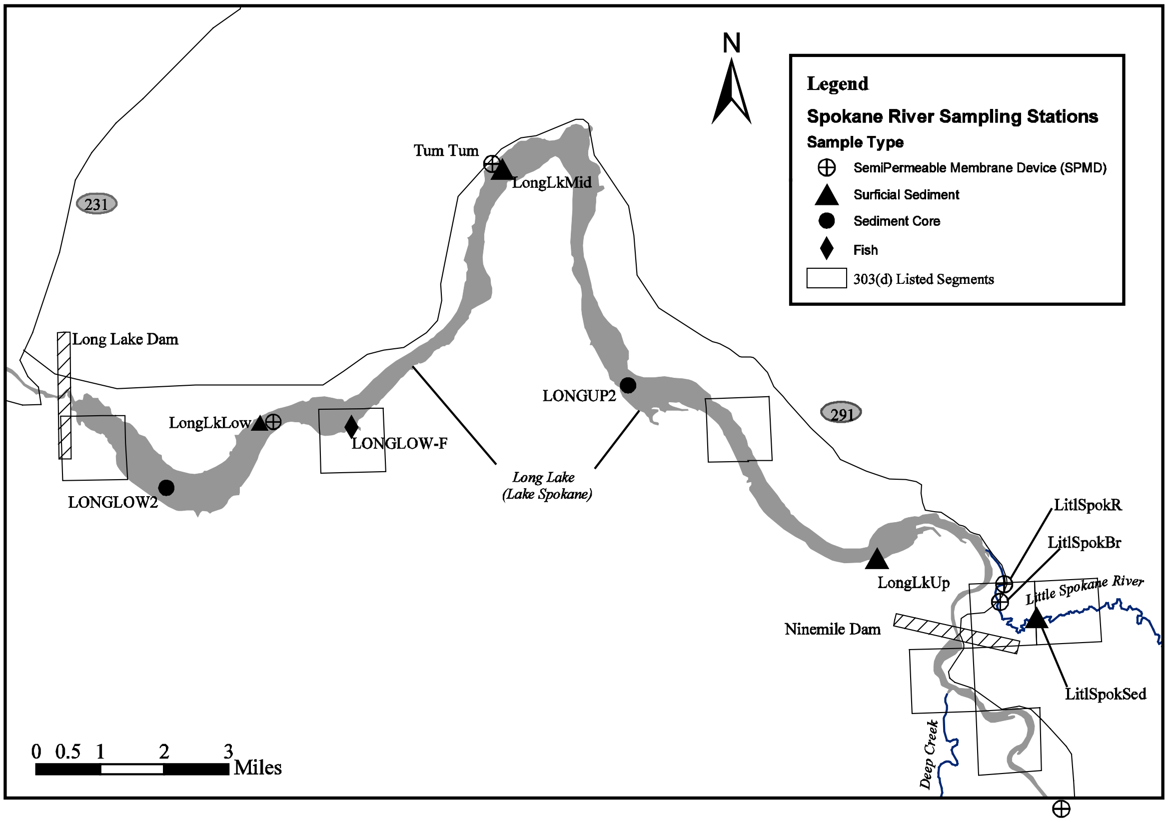

Figure 8. Sampling Map 2: Long Lake (Lake Spokane) Dam to Ninemile Dam.

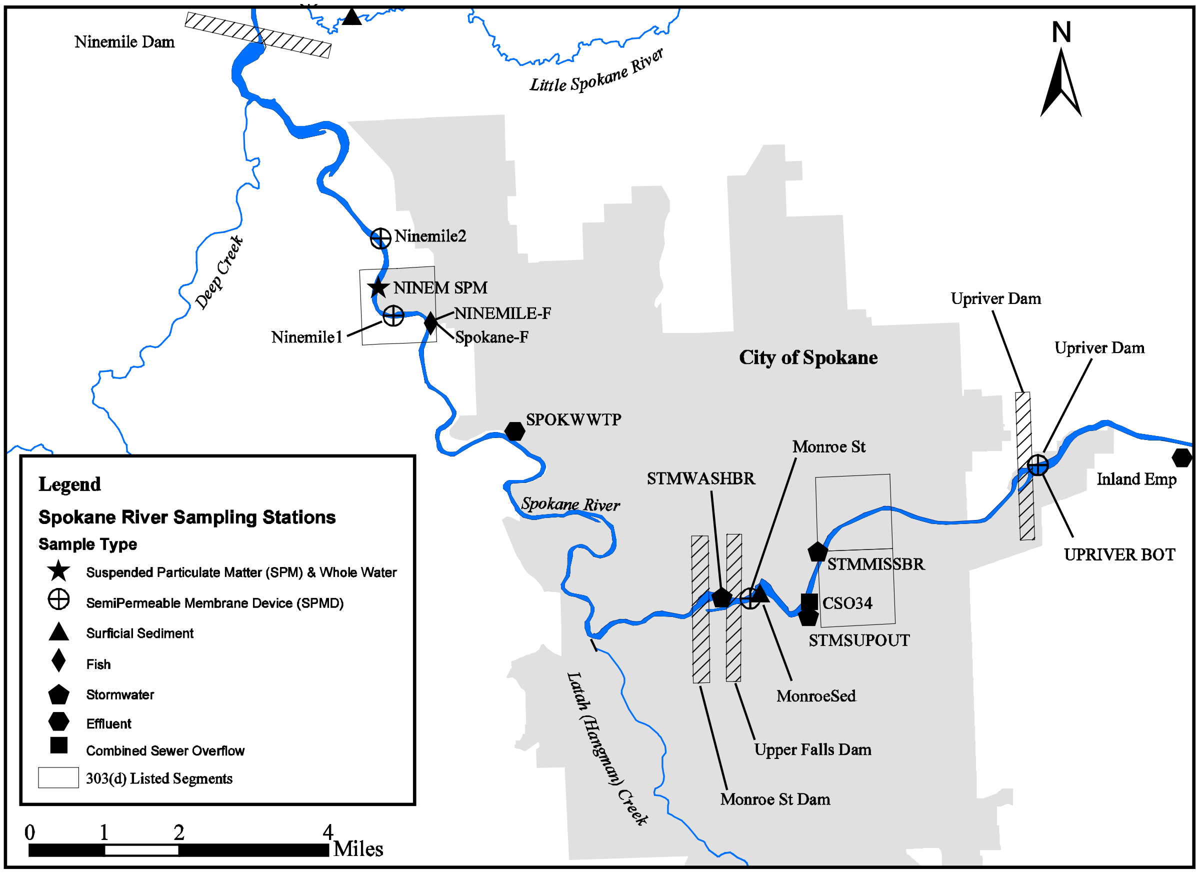

Figure 9. Sampling Map 3: Ninemile Dam to Upriver Dam.

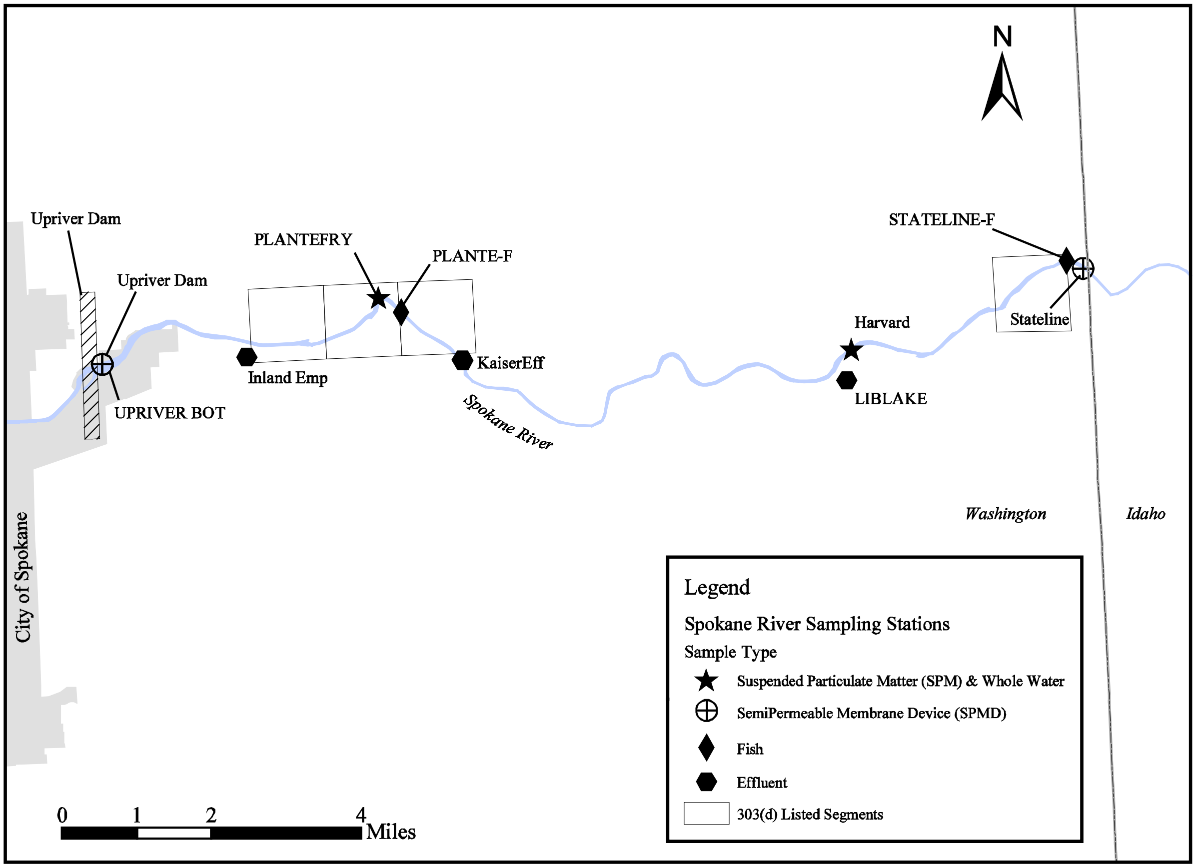

Figure 10. Sampling Map 4: Upriver Dam to Idaho Border.

Surface Water

Semipermeable Membrane Devices

Surface water at five Spokane River and one Little Spokane River locations was sampled using semipermeable membrane devices (SPMDs) obtained from Environmental Sampling Technologies (EST). SPMDs are passive samplers which consist of a 91 x 2.5 cm lay-flat polyethylene membranes filled with 1 mL triolein, a synthetic lipid that mimics biological uptake of dissolved organic compounds like PCBs. Membranes are mounted on "spider carriers" that hold the membranes during deployment and placed inside perforated stainless steel canisters, up to five membranes per can. The chemical residues accumulated in an SPMD can be used to calculate the ambient water column concentration for the chemicals of interest. Detailed information on SPMDs is in Appendix C. Table 8 shows locations where SPMDs were deployed.

Table 8. Locations and Dates of SPMD Deployments.

Location	Station	RM	Dates
State line	Stateline	96.1	10/1 - 10/29/2003 1/28 - 2/24/2004 4/14/04 - 5/12/2004
Behind Upriver Dam at mid-depth	Upriver Dam	80.3	10/1 - 10/29/2003 1/28 - 2/25/2004 4/14 - 5/12/2004
Behind Upriver Dam near bottom	UPRIVER BOT	80.3	10/1 - 10/29/2003 1/28 - 2/25/2004 4/14 - 5/12/2004
Behind Monroe St./Upper Falls Dam	Monroe St	74.8	10/2 - 10/29/2003 1/28 - 2/25/2004 4/14 - 5/12/2004
Ninemile Dam Pool upstream of Plese Flats	Ninemile1	63.6	10/1 - 10/29/2003 1/28 - 2/24/2004*
Ninemile Dam Pool near Sevenmile Bridge	Ninemile2	62.4	4/14 - 5/12/2004
Tum Tum	Tum Tum	44.2	1/29 - 2/24/2004
Lower Lake Spokane	LongLkLow	38.4	10/2 - 11/4/2003 4/13 - 5/11/2004
Little Spokane River at Rt. 291 bridge	LitlSpokBr	1.1	1/29 - 2/24/2004 4/14 - 5/12/2004
Little Spokane River ½ mile upstream of mouth	LitlSpokR	0.5	10/2 - 10/30/2003

*SPMD lost.

Canisters were deployed in the middle of the water column at Stateline, behind Upriver Dam, behind Upper Falls Dam (Monroe St.), upstream of Seven Mile Bridge (Ninemile), in Lake Spokane, and in the Little Spokane River near the mouth. In addition to the mid-depth SPMDs, deployments were also done approximately one foot above the bottom at the Upriver Dam site. The project plan called for one additional SPMD deployment in the lower two miles of Deep Creek, but the creek was too shallow for the sampler (Jack et al., 2003).

SPMD deployments occurred during October 2003, January-February 2004, and April-May 2004. These periods were selected to represent a range of river conditions: low flow in October, moderate flow in February, and high flows during spring runoff. Exposure periods were generally 28 days.

On arriving at the sampling site, the cans were opened, spider carriers were slid into the canisters, and the device was suspended in the water column. Because SPMDs are potent air samplers, the procedure was done as quickly as possible, typically one minute or less. Air exposure times were recorded for each event. Three SPMD membranes were used in each canister, with two canisters per sampling site. The dual canisters were used to minimize the risks of loss or vandalism. If both canisters were successfully recovered, the six membranes were combined for extraction. During each deployment period, one of the SPMD pairs from Upriver Dam was analyzed separately as a replicate. The dual canisters were deployed several meters apart at each station.

In some cases, alternative site selection was necessary due to variable flows or ice. The Lake Spokane SPMD was moved upstream to Tum Tum in January-February because the lower lake was frozen. The April deployment at Ninemile was moved downstream due to high flows, and the Little Spokane site was moved upstream from its original location for February and April sampling to improve accessibility. One of the two canisters was lost at Ninemile during October and at Stateline in April-May. In both instances the single canister (with three membranes each) contained enough material for complete analysis without compromising data quality. Both canisters were lost from Ninemile during January-February, the only event with lost data.

The SPMD retrieval procedure was essentially the opposite of deployment. Cans holding the SPMDs were sealed and shipped back to EST for extraction. EST then shipped the extracts to an accredited contract laboratory, Pace Analytical Services Inc., for PCB analysis.

A trip/field blank was prepared for each SPMD deployment by exposing dedicated membranes to air for the average time sample membranes were exposed. Trip blank membranes were treated the same as other membranes before and after sampling.

Temperature was monitored at 30-minute intervals throughout each deployment using a Tidbit® or I-button® temperature logger attached to the SPMD canister. At the beginning and end of each deployment period, grab samples for total organic carbon (TOC), dissolved organic carbon (DOC), and total suspended solids (TSS) were collected.

Suspended Particulate Matter and Whole River Water

Suspended particulate matter and whole water samples were collected at several locations to further assess water column PCB concentrations. Since hydrophobic organic chemicals like PCBs preferentially sorb to suspended particles, concentrations are more readily detectable, making it a useful surrogate for whole water. Suspended particles were collected using Sedisamp II continuous-flow centrifuges (model 101IL) in a manner described by Serdar et al. (1997) and previously used to collect particles in the Spokane River (Ecology, 1995). Table 9 shows locations and dates for sampling.

Table 9. Locations and Sampling Dates for Suspended Particulate Matter and Whole River Water.

Location	Station	RM	Dates (2003)
Harvard Road	Harvard	92.8	10/20 – 10/22
Plante Ferry Park	PLANTEFRY	84.8	10/28 – 10/30
Ninemile Pool at Plese Flats	NINEM SPM	63.2	11/3 – 11/5

A peristaltic pump set at a rate of 3-4 L/min. was used to draw water from an intake strainer situated in the middle of the water column approximately 10-20 meters offshore. All tubing and fittings were Teflon®, except for Silastic® tubing used at the pump head, and all centrifuge bowl parts in contact with samples were high quality stainless steel.

Water samples for TSS were collected from the centrifuge intake and outlet water each day to estimate particle removal efficiency. TOC and DOC samples were also collected during suspended particle sampling. Aliquots of intake water were periodically collected to provide a composite sample of whole river water for PCB analysis. Once sufficient material was obtained, the centrifuges were disassembled. Then the particulate matter was removed using a Teflon® spatula, and the particulate matter placed in appropriate sample containers. All samples were stored on ice in locked coolers while in the field.

Total mass of particulate matter collected was 9-17 g (dry weight), extracted from 8,700-9,600 L of river water. TSS concentrations in whole river water averaged 1-2 mg/L, and no TSS was detectable in the centrifuge outlet water at a reporting limit of 1 mg/L. Based on the average TSS values in the river and the dry weight of the particulate matter collected, the centrifuge extraction efficiencies were 71-89%, which is in the range of typical values using these centrifuges in similar water conditions (Yake, 1993). Ancillary data for suspended particulate samples are in Appendix D.

Effluents

Industrial and Municipal Wastewater Effluent

Final effluent from wastewater streams of four facilities were collected during unannounced visits on three occasions (Table 10). Samples were composites from two consecutive days, except at Kaiser Trentwood where final effluent was collected as discrete samples each day. Composite grab samples were also collected at the Kaiser wastewater stabilization lagoon and at the outlet of bed filters to assess the effect of particle removal on PCB concentrations.

Table 10. Outfall Locations and Dates of Industrial and Municipal Wastewater Effluent Samples.

Facility	Station	RM	Dates
Liberty Lake Sewer District WWTP	LIBLAKE	92.7	10/21– 22/2003 2/2 – 3/2004 4/26 – 27/2004
Kaiser Trentwood - Effluent	KaiserEff	86.0	10/21 – 22/2003 2/2 – 3/2004 4/26 – 27/2004
Kaiser Trentwood - Lagoon	KaiserLag	--	10/21 – 22/2003 2/2 – 3/2004 4/26 – 27/2004
Kaiser Trentwood - Below Filter	KaiserFilt	--	10/21 – 22/2003 2/2 – 3/2004 4/26 – 27/2004
Inland Empire Paper Company	Inland Emp	82.5	10/21 – 22/2003 2/2 – 3/2004 4/26 – 27/2004
City of Spokane WWTP	SPOKWWTP	67.4	10/21 – 22/2003 2/2 – 3/2004 4/26 – 27/2004

Samples were obtained by dipping a pre-cleaned glass container into the waste stream, either by hand or a stainless steel pole. Two-day composites included two quart grabs per day (morning and afternoon). A transfer blank was also collected during each round of sampling by pouring deionized water prepared at Manchester Environmental Laboratory into sample containers while on site. TSS samples were also collected as two-day grab composites at all facilities. Samples were placed on ice while in the field and maintained in coolers for transport with a chain-of-custody record.

Urban Stormwater

2004 Sampling

Three storm drains and one CSO were sampled during June 2004 (Table 11). Sampling was conducted by City of Spokane personnel during a runoff event produced by approximately 0.5 inches of rain in a 24-hour period. This event represented approximately one-half of the total precipitation for the month.

The storm-drain and CSO sites were selected by City of Spokane personnel based on recommendations by Ecology that the sites should be heavily developed with industrial land use preferred, outfalls should be upstream of the Monroe St. Dam, and at least one should be a CSO outfall.

Table 11. Outfall Locations and Date of 2004 Storm Drain and CSO Samples.

Drain	Station	RM	Date
Mission Ave. and Perry St.	STMMISSBR	76.5	6/10/04
CSO at Erie St.	CSO34	75.8	
Superior St. near Cataldo St.	STMSUPOUT	75.7	
Washington St. Bridge	STMWASHBR	74.3	

The plan called for five storm drain/CSOs sampled during two runoff events, but a lack of precipitation, poor timing, and interference with other priorities of the City's stormwater sampling program precluded the successful completion of the plan.

2007 Contracted Sampling

In 2007 Ecology commissioned Parsons Inc. to conduct a Spokane stormwater study that sampled 14 sites including the four previously sampled storm drains/CSO. Stormwater sites were selected to be within the city limits and to discharge stormwater directly to the Spokane River. Parsons' subcontractor, TerraGraphics Environmental Engineering Inc., collected stormwater grab samples for PCBs and TSS during three storm events in May and June of 2007. The storm-event rainfall measured ranged from 0.29 to 0.86 inches and was preceded by more than four days of dry weather (Parsons, 2007).

Stormwater sampling locations for the Parsons study are described in Table 12.

Table 12. 2007 Stormwater Sampling Locations

Location ID	City Manhole Identifier	Latitude†	Longitude†	Location Description
STMWTR_ HWY291	0106436ST	47.73423	-117.507	Near the southwest corner of the intersection of Parkway Road and Ninemile Road (Hwy 291).
STMWTR_ 7TH	2000318ST	47.64898	-117.445	Next to light pole on southeast side of curb at intersection of 7th Street and Inland Empire. This is a combined sewer overflow (CSO 26).
STMWTR_ HSTREET	0400621ST	47.69031	-117.464	In the middle of H Street next to the alley north of Glass and south of Northwest Boulevard. This is a combined sewer overflow (CSO 07).
STMWTR_ COCHRAN	0501142ST	47.68353	-117.448	In the middle of Cochran Street, north of Grace Avenue west of TJ Meenach Drive Southern (and downstream) of two manholes.
STMWTR_ LINCOLN	0906615IN	47.66256	-117.425	Catch basin in sidewalk east of Lincoln Street next to Anthony's Restaurant, north of Post Street Bridge.
STMWTR_ CLARKE	1900330ST	47.65836	-117.439	Off north side of the curb of Clarke Street, east of Elm Street. This is a combined sewer overflow (CSO 24A).
STMWTR_ HOWARDBR	1000124ST	47.66485	-117.421	Northeast of Howard Bridge (walking bridge), just south of intersection with Mallon Avenue. In the middle of the trail. South of circle, approximately 12 feet east of catch basin, near map sign.
STMWTR_ UNION	1382924ST	47.66148	-117.392	In the middle of the street in front of the Union Gospel Mission, just south of intersection of Erie Street and Trent Avenue.
STMWTR_ RIVERTON	1800130ST	47.66751	-117.389	At the intersection of South Riverton Avenue and Desmet Avenue on the river side of the guardrail.
STMWTR_ GREENE	1680120ST	47.67772	-117.364	South of the Greene Street bridge, located on the sidewalk east of the bridge.
STMWTR_ WASHINGT	1100230ST	47.664	-117.418	North and west of Washington Street bridge. Located where the two paved walking trails converge. Previously named "stmwashbr."
STMWTR_ SUPERIOR	1300136ST	47.66579	-117.393	In the middle of Superior Street, south of Cataldo Avenue. Previously named "stmsupout ."
STMWTR_ ERIECSO	0521966CD	47.66108	-117.393	South of Trent Avenue on Erie Street south of site 4217. Middle of three manhole covers in parking area of park. This is a combined sewer overflow (CSO 34). Previously named "CS034."
STMWTR_ MISSION	1400224ST	47.67227	-117.39	Northeast of the intersection of Perry Street and Mission Avenue near Avista. Previously named "stmmissbr ."

† in decimal degrees
From Parsons, 2007.

Bottom Sediment

Surficial Deposits

Ecology collected surficial (top 2 cm) bottom sediments at several locations in the Spokane River, Little Spokane River, and a reference site. Surface sediment samples were collected from an Ecology boat using a 0.1 m^2 stainless steel van Veen or a 0.01 m^2 Petite Ponar grab sampler. Sediments from the Little Spokane were taken from the right bank using a pipe dredge. Sites were selected to assess the possibility of high concentrations of PCBs behind Monroe St. Dam, assess the longitudinal PCB concentration gradient in Lake Spokane, evaluate the potential of the Little Spokane River as a significant PCB source, and assess PCB concentrations in previously unexamined Spokane River reaches downstream of Lake Spokane.

The same reference site (Buffalo Lake) selected for an earlier bioassay survey of the Spokane Arm of Lake Roosevelt (Era-Miller, 2004) was used to provide reference sediments for the present 2003-07 study. It is located in a remote area of Okanogan County west of Spokane and receives contamination only through atmospheric deposition. An EPA study conducted during 2002 found low a PCB concentration (5.6 ng/g total PCBs) in largemouth bass fillets from Buffalo Lake (unpublished EPA data).

Table 13 lists locations for surficial sediment sampling. The riverbed behind the Monroe St. Dam in the vicinity of RM 76 and downstream of Little Falls Dam in the vicinity of RM 18-29 was composed almost entirely of gravel and cobble, and therefore no samples were collected.

Table 13. Locations and Dates of Surficial Sediment Samples.

Location	Station	RM	Date
Behind Monroe St./Upper Falls Dam	MonroeSed	74.9	4/14/2004
Lake Spokane (Long Lake)	LongLkUp	54.3	5/11/2004
	LongLkMid	44.3	11/4/2003
	LongLkLow	38.4	11/4/2003
Little Falls Pool	Littlefls	29.9	11/4/2003
Spokane Arm at Porcupine Bay	SPOK-1	12.6	11/6/2003
Little Spokane River	LitlSpokSed	2.3	12/10/2003
Buffalo Lake (reference)	BUFFALO REF	--	11/5/2003

Sediment Cores

Ecology collected sediment cores from the upper and lower reaches of Lake Spokane to assess trends in historic PCB deposition and to estimate sediment recovery rates (Table 14). Cores were collected using a Wildco 50-cm stainless steel gravity box corer fitted with a 13 cm by 13 cm (inner diameter) transparent acrylic liner.

Table 14. Locations and Dates of Sediment Cores.

Location	Station	RM	Date
Upper Lake Spokane	LONGUP2	49.2	6/9/2004
Lower Lake Spokane	LONGLOW2	36.0	11/4/2003

Fish and Crayfish Tissue

Ecology obtained fish and crayfish for PCB analysis from seven locations in the Spokane River from 2003 to 2005 (Table 15). For 2003 and 2004, the goal was to collect rainbow trout (>250 mm) and two size classes of largescale suckers (250-350 mm and <200 mm) at each site except Upriver Dam. Crayfish were collected at Upriver Dam due to interest in their possible accumulation of PCBs at the cleanup site. All biological data on specimens used for analysis are in Appendix E.

The goal for 2005 sampling was to provide high quality representative data to WDOH for use in a human health assessment and in reviewing the current fish consumption advisory stemming from data collected in 1999 and 2001. A secondary objective was to examine contaminant trends within the river system. Rainbow trout were not found during extensive efforts to capture them at Stateline and lower Lake Spokane. Largescale suckers were numerous at all sites except in the Ninemile reach where bridgelip suckers were the dominant species. The smaller size class of largescale suckers was not found at any of the sites sampled, even when various capture methods were employed.

Fish were collected primarily using Ecology's 16' Smith-Root electrofishing boat. Largescale suckers from Lake Spokane were captured using variable mesh gillnet sets on the lake bottom. Specimens were held in the vessel's live well and checked for species identification and desired length. Crayfish were collected using basket-cone style crayfish traps baited with cat food and set on the bottom overnight.

Fish selected for analysis were killed by a blow to the head. Each fish was given a unique identifying number, and its length and weight were recorded. The fish were individually wrapped in aluminum foil, put in plastic bags, and placed on ice for transport to Ecology headquarters, where the samples were frozen pending preparation of the tissue samples.

Crayfish were placed in a pre-cleaned 1 gallon glass jar and held on ice in coolers while in the field. Upon returning to Ecology headquarters, specimens were measured, weighed, and identified using an invertebrate species key. Following identification, specimens were returned to the jar and frozen until resection.

Table 15. Locations and Dates of Fish and Crayfish Samples.

Location	Station ID	RM	Latitude	Longitude	Species	Tissue	Dates
Near state line with Idaho	STATELINE-F	96.0	47.6981	-117.044	Largescale sucker	Whole body	7/14/04[*]
	SPK 96	96.0	47.69832	-117.044			8/22/05[†]
Near Plante Ferry Park	PLANTE-F	85.0	47.69459	-117.239	Rainbow trout	Fillet Gut contents	9/15/03[*]
					Largescale suckers	Whole body Gut contents	
	SPK 85	85.0	47.69498	-117.24	Rainbow trout Largescale suckers	Fillet Whole body	8/23/05[†]
Behind Upriver Dam	Upriver Dam	80.3	47.6869	-117.325	Crayfish	Tail muscle	5/13/04[*]
Mission Park	SPK 77	77.0	47.67655	-117.382	Mountain whitefish	Fillet	9/28/05- 9/29/05[†]
	SPK 75.2	75.2	47.66401	-117.404	Largescale sucker Rainbow trout	Whole body Fillet	9/28/05[†]
Ninemile reservoir (near Seven Mile Bridge)	Spokane-F	61.7	47.7324	-117.51	Rainbow trout	Fillet	9/16/03[*]
	NINEMILE-F	61.7	47.74299	-117.522	Rainbow trout	Gut contents	
	NINEMILE-F	61.7	47.74299	-117.522	Bridgelip sucker	Whole body Gut contents	7/13/04[*]
	SPK 64.0	64.0	47.72043	-117.501	Rainbow trout	Fillet Whole body	9/29/05[†]
					Mountain whitefish	Fillet Whole body	
					Bridgelip sucker	Fillet Whole body	
Upper Lake Spokane	SPK 55.6	55.6	47.80089	-117.549	Largescale sucker Smallmouth bass Mountain whitefish	Whole body Fillet Fillet	9/27/05[†]
	SPK 55.2	55.2	47.80156	-117.558	Brown trout	Fillet	11/3/05[†]
Lower Lake Spokane	SPK 40.1	40.1 40.8	47.83472 47.84152	-117.737 -117.725	Mountain whitefish Smallmouth bass	Fillet Fillet	11/3/05[†]
	LONGLOW-F	39.4	47.82769	-117.745	Largescale sucker	Whole body	7/13/04- 7/14/04[*]

[*] Sampling conducted in support of the present study. See Jack et al. (2003) for Quality Assurance Project Plan.
[†] Serdar and Johnson (2006).

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Sample Preparation

Sample containers and holding times for 2003-2005 are shown in Table 16. The fish and crayfish tissue preparation techniques used are described in Appendix F. See Parsons (2007) for sample preparation, analytical methods, and data quality information for stormwater samples collected in 2007.

Analytical Methods

All PCB congener samples and percent lipid in tissue were analyzed at Pace Analytical Services, Inc., Minneapolis, MN. PCB Aroclors, TOC in sediments, and TOC, DOC, and TSS in water were analyzed at Manchester Environmental Laboratory. SPMD preparation and dialysis was done at Environmental Sampling Technologies (EST), St. Joseph, MO. Radioisotope analysis of sediment cores was done at Teledyne Brown Engineering, Knoxville, TN. Grain size analysis was done at Analytical Resources, Inc., Tukwila, WA.

Table 16 shows analysis methods and reporting limits for sample media.

Table 16. Preparation Methods, Analytical Methods, and Reporting Limits for the Spokane River Samples.

Sample Media	Parameter	Preparation Method	Analytical Method	Reporting Limits
Semipermeable Membrane Device (SPMD)	PCB Congeners	Dialysis and ampulization - EST SOP	GC/HRMS, EPA Method 1668A	100 ng/4 ML dialysate (per congener) translates to approx. 0.1 - 1 pg/l (per congener)
Water	PCB Congeners	--	GC/HRMS, EPA Method 1668A	100 pg/l (per congener)
	TSS	--	EPA Method 160.3	1 mg/L
	TOC	--	EPA Method 415.1	1 mg/L
	DOC	--	EPA Method 415.1	1 mg/L
Sediment (Suspended particulate matter and surficial sediment)	PCB Congeners	Soxhlet extraction	GC/HRMS, EPA Method 1668A	0.05 ng/g (per congener)
Sediment	PCB Congeners	Soxhlet extraction	GC/HRMS, EPA Method 1668A	0.05 ng/g (per congener)
	TOC (104 °C)	--	Combustion	0.1%
	Grain size	--	Sieve and Pipet	±0.5% for each fraction
Sediment (Core)	PCB Aroclors	Soxhlet extraction	GC/ECD, EPA Method 8082	1 - 25 ng/g (per Aroclor)
	TOC (104 °C)	--	Combustion	0.1%
	Pb-210	--	Gamma detection	--
Tissue	PCB Congeners	Soxhlet extraction	GC/HRMS, EPA Method 1668A	0.01 - 0.05 ng/g (per congener)
	% lipids	--	Gravimetric	0.1%

SOP = Standard operating procedure.

Data Quality Assessment

Ecology's Manchester Laboratory reviewed the chemical data for this project. For results generated by Manchester, final data review was performed by the unit supervisor or an analyst experienced with the method. Manchester chemists performed the review for analytical work sub-contracted to commercial laboratories. Quality assurance and quality control at Manchester are described in the *Lab Users Manual* http://aww.ecologydev/programs/eap/forms/labmanual.pdf (Ecology Intranet).

Manchester prepared written case narratives assessing the quality of all data collected. These reviews include a description of analytical methods and an assessment of holding times, initial and continuing calibration and degradation checks, method blanks, surrogate recoveries, internal standard recoveries, matrix spike recoveries, laboratory control samples, and laboratory duplicates. The reviews and the complete Manchester data reports are available from the author on request.

A Quality Assurance Project Plan (Jack, 2003) established measurement quality objectives (MQOs) for accuracy, bias, and reporting limits. To determine if MQOs were met, the project lead compared results on field and laboratory quality control samples to the MQOs. To evaluate whether the reporting limit targets were met, the results were examined for non-detects and to determine if any values exceeded the lowest concentration of interest. Based on these assessments and a review of the laboratory data packages and Manchester's data verification reports, the data were either accepted, accepted with appropriate qualifications, or rejected and re-analyzed or re-sampled where possible.

The precision and accuracy of the 2003-2005 data reported here can be gauged from results on laboratory duplicates, field replicate samples, and standard reference materials, detailed in Appendix G. The relative percent difference (RPD) between duplicate (split) and replicate (separately collected) samples was 20% or better for PCBs in effluents, fish tissue, and sediment. Greater variability was encountered in analyzing PCBs in SPMD extracts, 9-55% RPD. Results from analyzing PCB congeners in a sediment standard reference material agreed within 13% of certified values, on average.

Results and Discussion

Dissolved PCBs in Spokane River Water

Ancillary water quality data collected in concert with SPMD deployments are shown in Table 17. Organic carbon concentrations were low at all sites. DOC constituted approximately 92% of the TOC on average. TSS concentrations were generally ≤3 mg/L with higher values (4-10 mg/L) occurring in February and April.

With a few exceptions, average temperatures were similar at all mainstem locations during each deployment. Stateline and Lake Spokane were approximately 1.5ºC warmer than other sites in October, but Stateline temperatures were slightly colder in February. Lake Spokane temperatures were also the warmest among mainstem sites in February. At Upriver Dam, bottom and middle water column temperatures were nearly identical.

Dissolved PCB concentrations determined from analyzing the SPMD membranes are shown in Table 18. A summary of the PCB residues accumulated in the membranes (raw data) is in Appendix C.

Concentration estimates for dissolved total PCBs ranged from 34 pg/l (parts per quadrillion) at Stateline during February (2004) to a maximum of 656 pg/l at lower Lake Spokane during October (2003). PCBs were composed primarily of tri- through heptachlorobiphenyl congeners. Spokane River total PCBs showed a fairly consistent trend of increasing concentrations moving downstream. Generally, dissolved total PCB concentrations were comparatively low at Stateline and Upriver Dam (34-145 pg/l), intermediate at Monroe St. and Ninemile (76-305 pg/l), and highest at Lake Spokane (78-656 pg/l). Total PCB concentrations in the Little Spokane River were 118-178 pg/l. The PCB mixture in the Little Spokane was enriched in octa, nona, and deca homologues compared to the mainstem Spokane River, suggesting a difference in sources.

There was evidence of seasonal differences in total PCB levels, with concentrations highest during October and lowest during February (Figure 11). Total PCB measured during October and April appeared similar at all reaches except for a large divergence at Lake Spokane. One possible reason for the much higher PCB concentration in Lake Spokane in October is the fall breakdown of stratification, which allowed bottom water enriched in PCBs to mix with the upper water column. This is consistent with SPMD findings for Upriver Dam, discussed below.

Table 17. Ancillary Parameters at SPMD Sites (mg/L).

Station Name	Sample Number	Collection Date	DOC		TOC		TSS		Mean Temp. (ºC)
Stateline	3408971	10/1/03	1.1		1.3		1	U	14.4
	3448107	10/29/03	1.1		1.2		2		
	4058111	1/28/04	1.4		1.3		1	U	3.2
	4094040	2/24/04	1.2		1.3		1		
	4164041	4/14/04	1.2		1.6		3		10.8
	4208134	5/12/04	1		1.2		2		
Upriver Dam	3408966/72*	10/1/03	1.2		1.5		2		12.7
	3448108	10/29/03	1		1.2		1		
	4058112	1/28/04	1.2		1.4		1		3.5
	4094044/5*	2/25/04	1.2		1.3		2		
	4164042/3*	4/14/04	1.6		1.7		3		10.8
	4208135	5/12/04	1		1.1		2		
UPRIVER BOT	--	10/1/03	--		--		--		12.7
	--	10/29/03	--		--		--		
	--	1/28/04	--		--		--		3.6
	4094046	2/25/04	1.1		1.3		2		
	4164044	4/14/04	1.3		1.4		3		9.8
	4208136/7*	5/12/04	1.1		1.1		2		
Monroe St	3408968	10/2/03	1	U	1	U	1	U	12.0
	3448109	10/29/03	1	U	1.1		1		
	4058113	1/28/04	1	U	1.1		2		4.0
	4094047	2/25/04	1.2		1.2		1		
	4164045	4/14/04	1.4		1.3		3		10.8
	4208138	5/12/04	1	U	1.3		2		
Ninemile1	3408967	10/1/03	1	U	1	U	1	U	12.3
	3448110	10/29/03	1.1		1.3		2		
	4058114/5*	1/28/04	1.2		1.3		2		--
	4094041	2/24/04	1.4		1.8		4		
Ninemile2	4164046	4/14/04	1.4		1.4		6		10.8
	4208139	5/12/04	1		1.1		2		
LongLkLow	3408969	10/2/03	1.1		1.1		2		14.4
	3454120	11/4/03	1	U	1	U	2		
	4164040	4/13/04	1.1		1.5		4		10.8
	4208133	5/11/04	1.1		1.3		3		
Tum Tum	4058117	1/29/04	1		1.1		2		4.5
	4094043	2/24/04	2.1		2.6		4		
LitlSpokR	3408970	10/2/03	1	U	1	U	1		
	3448111	10/30/03	1	U	1	U	2		14.4
LitlSpokBr	4058116	1/29/04	1	U	1	U	8		4.5
	4094042	2/24/04	2.7		2.2		10		
	4164047	4/14/04	1.3		1.7		7		
	4208140	5/12/04	1.1		1	U	5		10.8

*Mean of replicate analysis.
U: The analyte was not detected at or above the reported result, equivalent to <1.
Stateline: Spokane River at the Idaho state line just downstream of Interstate 90 bridge.
Upriver Dam: Spokane River upstream of Upriver Dam.
UPRIVER: Spokane River upstream of Upriver Dam, 2 feet from bottom of riverbed.
Monroe St: Spokane River upstream of Monroe Street Dam.
Ninemile1: Spokane River at Riverside State Park.
Ninemile2: Spokane River downstream of boat launch at Plese Flats
LongLkLow: Lower Lake Spokane.
Tum Tum: Lake Spokane near Tum Tum.
LitlSpokR: Little Spokane River at State Route 291 bridge.

Table 18. SPMD Dissolved PCB Concentrations Grouped by Homologues (pg/l), 2003-2004.

Station Name	Sample Number	1-Cl	2-Cl	3-Cl	4-Cl	5-Cl	6-Cl	7-Cl	8-Cl	9-Cl	10-Cl	Total PCBs
October 2003												
Stateline	474155	0.4	1.5	11	15	56	19	7.9	2.4	0.0	0.0	113
Upriver Dam	474156/7*	0.7	5.5	25	26	32	10	3.7	0.0	0.0	0.0	103
UPRIVER BOT	474158	0.4	5.0	31	48	43	13	4.8	0.7	0.0	0.0	145
Monroe St	474159	0.6	8.6	32	60	65	42	18	3.0	0.0	0.0	231
Ninemile1	474160	0.3	13	63	61	95	49	21	3.1	0.0	0.0	305
LongLkLow	474161	0.7	15	59	269	195	74	32	9.3	2.3	0.0	656
LitlSpokR	474162/3*	0.2	1.0	12	27	33	16	12	11	6.4	0.0	118
February 2004												
Stateline	194130	0.0	0.0	1.8	4.6	14	8.9	5.0	0.0	0.0	0.0	34
Upriver Dam*	194131/2*	0.1	0.6	5.6	12	15	3.7	19	0.0	0.0	0.0	56
UPRIVER BOT	194133	0.0	0.3	10	40	22	4.1	0.8	0.0	0.0	0.0	78
Monroe St	194134	0.0	1.0	9.5	21	20	13	11	0.0	0.0	0.0	76
Ninemile1	--	--	--	--	--	--	--	--	--	--	--	--
Tum Tum	194135	0.0	1.4	12	24	18	8.9	13	0.1	0.0	0.0	78
LitlSpokBr*	194136/7*	0.1	0.4	9.1	35	51	16	12	13	6.9	0.0	143
April 2004												
Stateline	208134	0.0	0.3	8.0	17	60	32	27	2.1	0.0	0.0	145
Upriver Dam	208135	0.0	0.0	2.1	16	14	6.6	4.6	0.9	0.0	0.0	45
UPRIVER BOT*	208136/7*	1.8	1.0	24	78	57	17	11	0.5	0.0	0.0	191
Monroe St	208138	0.1	1.8	21	53	80	40	31	4.0	0.0	0.0	231
Ninemile2	208139	0.5	2.6	25	57	68	40	28	3.9	0.0	0.0	225
LongLkLow	208133	0.6	6.0	25	94	84	34	16	3.3	0.0	0.0	263
LitlSpokBr*	208140/1*	0.4	0.8	18	37	53	19	23	14	10	3.1	178

*Mean of replicate analysis.
Note: Reporting limits were variable, 0.1 – 10 pg/l.

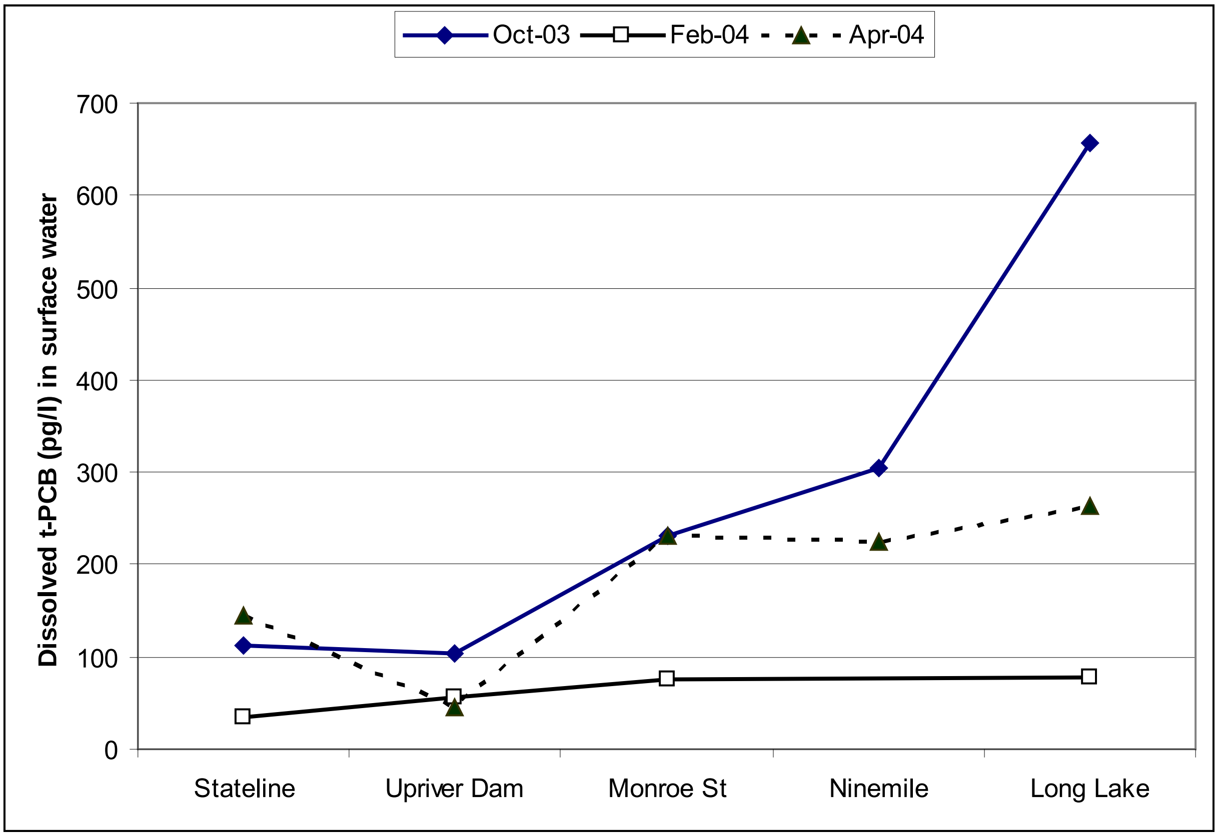


Figure 11. Dissolved Total PCBs in the Spokane River, 2003-2004.

Dissolved PCBs at Monroe Street, Ninemile, and lower Lake Spokane did not meet (exceeded) Washington State's human health water quality criterion of 170 pg/l. During October, the total PCB concentrations at these sites ranged from 231 to 656 pg/l. In April, the concentration range was 231 to 263 pg/l. The Little Spokane River was at the criterion in April (178 pg/l).

The February total PCB concentrations were similar among reaches and low compared to other months. Lower concentrations during this deployment may have been more a result of colder temperatures which reduce the SPMD sampling rate but is not accounted for in calculations used to translate SPMD PCB residues to surface water concentrations (see Appendix C). This may also explain the consistent total PCB concentrations in the Little Spokane River, since February and April temperatures at this location were 2-3ºC warmer. Simple flow dilution does not explain the differences among deployments since Spokane River discharge was highest during April (325 m^3/s at Spokane), lowest during October (49 m^3/s), and intermediate during February (114 m^3/s).

One objective of the SPMD sampling at the Upriver Dam cleanup site was to assess PCB levels at different depths. Samplers deployed 1-2 feet from the bottom had consistently higher concentrations than those at mid-depth (12-13 feet above bottom, Figure 12). The difference was pronounced in April when the bottom sample was four times the mid-column sample, even though the temperature was 1ºC lower (and thus a slightly lower sampling rate) at the bottom. Temperatures at both depths were identical during the other deployments.

At the time of sampling, higher PCB concentrations near the bottom were expected at this site which has PCB contaminated sediments that had yet to undergo state-directed cleanup (see previous Upriver Dam discussion). Although the high level of organic carbon in some of the PCB contaminated sediments theoretically sequesters PCBs, some diffusion to the water column occurs which was captured by the near-bottom SPMDs.

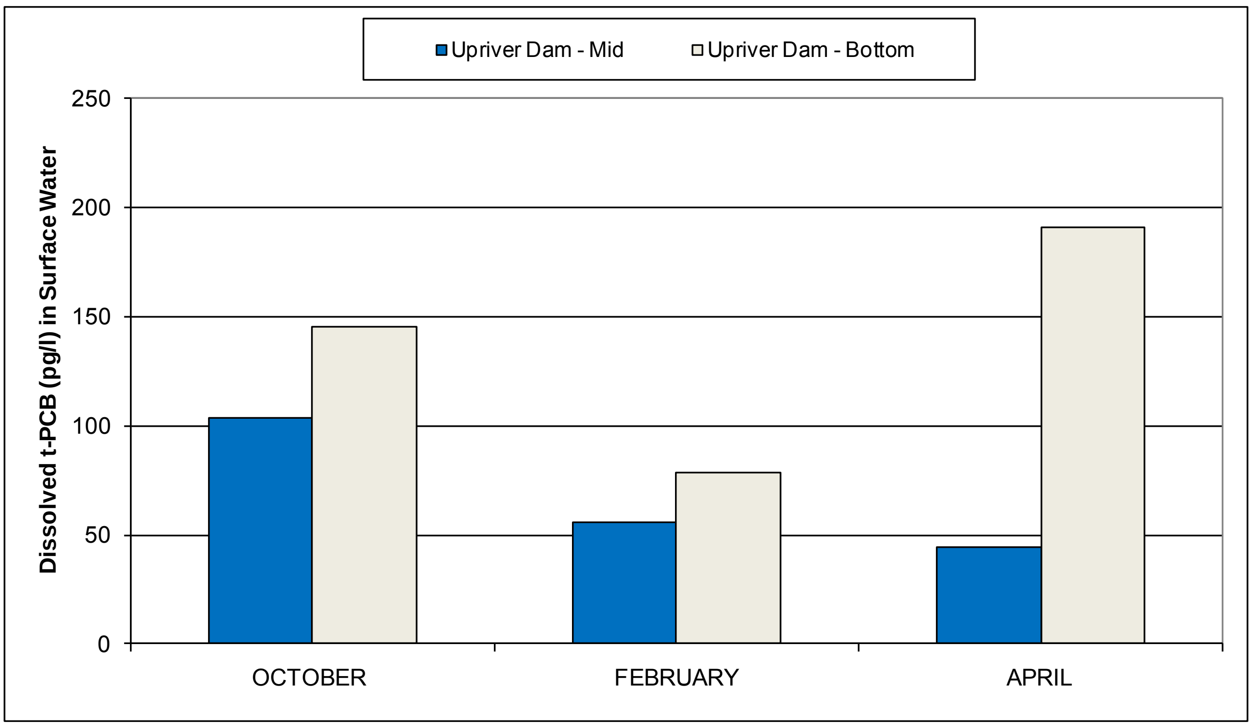


Figure 12. Dissolved Total PCBs at Mid-depth and Near the Bottom at Upriver Dam.

PCBs in Spokane River Suspended Particulate Matter

PCBs were measured in suspended particulate matter (SPM) and whole water from the Spokane River at Harvard Rd., Plante Ferry, and Ninemile during three two-day events in October-November 2003. For each sample collection (Oct 20-21, Oct 28-29, and Nov 3-4), a generator run pump was used to draw water up to a large centrifuge. Whole water samples were pumped to a sample container immediately upstream of the centrifuge. Ancillary water quality parameters included TOC, DOC, and TSS (Appendix D). TOC and DOC values were generally ≤1 mg/L. TSS averaged 1 mg/L at Harvard Road and Ninemile and 2 mg/L at Plante Ferry.

In SPM, PCBs were composed primarily of tetra-, penta-, and hexachlorobiphenyl congeners (Table 19). [Compared to dissolved PCBs which were composed primarily of tri- through heptachlorobiphenyl congeners. See previous discussion on dissolved results for the Spokane River.] Total PCB concentrations in suspended particles from Ninemile (69 ng/g, parts per billion) were an order of magnitude higher than those upstream (7.1-9.6 ng/g). The low TSS concentrations during all three sampling events indicate that differences in total PCB concentrations were not due to sediment entrainment.

For the most part, detection limits in the whole surface water samples were not low enough to afford a useful comparison with the SPM data. No PCBs were detected in the whole water samples collected at Harvard Rd. or Plante Ferry at the 110 pg/l level, and only a low concentration (130 pg/l) of dichlorobiphenyl congeners was detected at Ninemile (Table 19). This is an unusual finding considering the relatively low concentration of this homologue group in SPM and SPMDs.

Earlier (1994) SPM sampling by Ecology (1995) at Plante Ferry yielded much higher PCB concentrations (220 ng/g) using the same collection methods as the present 2003-07 study. Although that result was obtained using an Aroclor rather than congener analysis, river conditions were similar, TSS was low (<1 mg/L), and the sampling site was nearly identical.

To examine the proportion of solid and dissolved phase PCB concentrations in the Spokane River, the following partition formula was applied to the SPM data:

Equation 3. $$\boldsymbol{Fraction\ of\ dissolved\ PCB} = \frac{\mathbf{1}}{(\mathbf{1}+(\boldsymbol{f_s}*\boldsymbol{f_{oc}}*\boldsymbol{K_{oc}}))}$$

Where:

- f_s = fraction of solid in water.
- f_{oc} = fraction of organic carbon in the solid phase.
- K_{oc} = sediment-water partition coefficient normalized for organic carbon.

This formula assumes that PCBs are in equilibrium between the solid and dissolved phases, and the proportion in each phase is governed by the amount of solids in the water and the organic carbon content of the solid material. K_{oc}, the sediment-water partition coefficient normalized for organic carbon, is a field or laboratory-derived constant for each chemical. Values for f_s were from TSS measurements (1 or 2 mg/L; i.e., f_s = 0.000001 or 0.000002). Values for f_{oc} (0.15) and K_{oc} (449,000) are from EPA (1994) and DiToro et al. (1991), respectively, and are the same values used by Ecology (1995) to calculate a dissolved PCB concentration in water from earlier sampling.

Based on sediment-water partitioning, approximately 94% of the PCBs are in the dissolved phase. Dissolved total PCB concentration for Harvard Rd. and Plante Ferry are 142 and 105 pg/l, respectively, similar to results derived from SPMD deployments at Stateline and Upriver Dam during the same period (≈110 pg/l). The theoretical dissolved concentration of total PCBs was 1,020 pg/l at Ninemile, more than three times the concentration measured with SPMDs (305 pg/l) during October (in Table 18).

Table 19. PCB Concentrations Grouped by Homologues in Suspended Particulate Matter (ng/g, dw) and Whole River Water Collected at the Centrifuge Inlet (pg/l) During Three Sampling Events from October to November 2003.

	Station	Sample Number	1-Cl	2-Cl	3-Cl	4-Cl	5-Cl	6-Cl	7-Cl	8-Cl	9-Cl	10-Cl	Total PCBs
Suspended Particulate Matter													
Spokane R at Harvard Rd	Harvard	3438100	<0.09	0.11	0.51	0.96	2.91	3.40	1.39	0.32	<0.09	0.09	9.60
Spokane R at Plante Ferry Park	PLANTEFRY	3448100	<0.05	0.09	0.41	1.34	2.49	1.98	0.70	0.08	<0.05	0.05	7.09
Spokane R at Riverside State Park	NINEM SPM	3454105	<0.07	0.39	3.71	12.9	24.6	18.6	6.30	1.71	0.39	0.15	68.8
Whole Water Centrifuge Inlet													
Spokane R at Harvard Rd	Harvard	3438100	REJ	<111	<111	<111	<111	<111	<111	<111	<111	<122	<111
Spokane R at Plante Ferry Park	PLANTEFRY	3448100	<109	<109	<109	<109	<109	<109	<109	<109	<109	<120	<109
Spokane R at Riverside State Park	NINEM SPM	3454105	<108	130	<108	<108	<108	<108	<108	<108	<108	<119	130

Detected values are in green highlight.
<: The analyte was not detected at or above the reported result.
REJ: Data are unusable for all purposes.

Figure 13 shows the two-day whole water PCB concentrations estimated from the suspended matter data and illustrates the relative importance of the dissolved PCB component, at least during low-flow conditions. Results also suggest that the analysis of whole surface water samples collected during particulate matter sampling underestimated actual PCB concentrations.

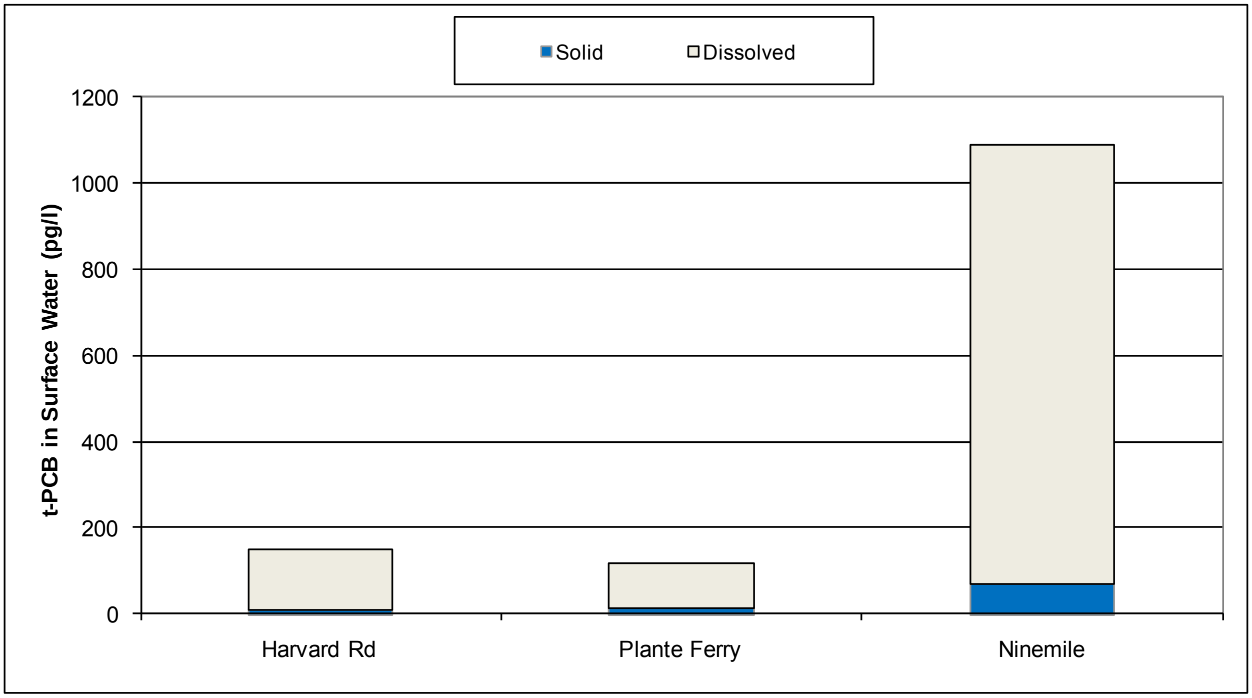


Figure 13. Measured Particle-Bound PCB Concentrations and Theoretical Dissolved PCB Concentrations Based on Suspended Particulate Matter Collected by Three 2-Day Centrifugation Sampling Events of Spokane River Water in October and November 2003.

PCBs in Industrial and Municipal Effluents Discharged to the Spokane River

In late 2003, Kaiser Trentwood installed a black walnut shell filtration system for their process wastewater discharge. Results of 2004-2005 effluent sampling showed an order of magnitude decrease in PCB concentrations and loads compared to 2001, presumably due to the filter and other facility management improvements. Table 20 shows the results of effluent PCB monitoring by Kaiser in 2004-2005 (unpublished).

Table 20. Kaiser Trentwood Effluent Concentrations of Total PCBs (Kaiser, 2005).

Source	Date	Total PCBs (pg/l)*	Effluent Flow (ML/day)	PCB Load to River (mg/day)
Kaiser Trentwood	6/25/04	1,170	63.9	75
	7/7/04	1,230	64.6	79
	7/23/04	1,340	66.2	89
	8/9/04	914	62.4	57
	4/20/05	669	56.2	38
	5/7/05	928	56.1	52
	5/19/05	1,370	59.7	82
	6/11/05	971	56.5	55
	6/14/05	1,130	55.4	63

*sum of detected congeners.

PCBs monitored by Ecology in effluents from four industrial and municipal facilities during three periods – October 2003, February 2004, and April 2004 – are shown in Table 21. Descriptions of the station names and sampling dates were listed in Table 10.

Spokane WWTP was the only facility where PCBs were detected in effluent during all three sampling collections, with an average PCB concentration of 940 pg/l.

Total PCBs in the Kaiser Trentwood effluent were generally <110 pg/l except during October when 330 pg/l was detected on 10/21/2003. Total PCBs were undetected at the 100 pg/l detection limit the following day. Samples from the treatment lagoon at Kaiser showed much higher PCBs (110 – 7,400 pg/l), but these concentrations were reduced substantially by the bed filtration system prior to discharge.

Liberty Lake WWTP had variable concentrations, as did Inland Empire to a lesser degree. Total PCB concentrations at Liberty Lake WWTP were an order of magnitude higher during April than during October and February, while Inland Empire had only one sample with PCBs detected, 670 pg/l total PCBs in October.

Overall, it appears that PCB concentrations in the effluents of the four facilities have decreased substantially since previous sampling. The smallest decrease occurred at the Spokane WWTP where 2003-04 average concentrations were about one-half those during 2001. However, the bulk of this apparent decrease may be due to higher detection limits used for the 2003-2004 samples compared to earlier samples. Effluent samples analyzed by Golding (2002) and SAIC (2003a) typically had detection limits <5 pg/l for individual congeners, and nearly all detected congeners were found at concentrations <100 pg/l. Therefore, the 2003-2004 results are likely all biased low due to the omission of these detections.

The reason for the relatively high level of monochloro-biphenyls in the 2004 Liberty Lake and Spokane WWTP replicate samples is unknown. The poor agreement between the Spokane WWTP replicate samples suggests contamination either from the field or laboratory. These values do not have a significant impact on the PCBs loading scenarios presented later in the report.

Table 21. PCB Concentrations Grouped by Homologues in Industrial/Municipal Effluent (pg/l).

Station Name	Sample ID	TSS mg/L	1-Cl	2-Cl	3-Cl	4-Cl	5-Cl	6-Cl	7-Cl	8-Cl	9-Cl	10-Cl	Total PCBs
October 2003													
LIBLAKE	3434025	7	<98	161	<98	<98	<98	<98	<98	<98	<98	<98	161
KaiserEff	3434020	1	<100	100 J	228	<100	<100	<100	<100	<100	<100	<110	328 J
KaiserEff	3434023	1	<101	<101	<101	<101	<101	<101	<101	<101	<101	<112	<101
KaiserLag	3434021	3	<102	292 J	911	1,350	<102	<102	<102	<102	<102	<112	2,550 J
KaiserFilt	3434022	1	<100	167 J	104	<100	<100	<100	<100	<100	<100	<110	271 J
Inland Emp	3434026	5	<101	670	<101	<101	<101	<101	<101	<101	<101	<111	670
SPOKWWTP	3434027	6	<99	143	<99	112	218	<99	<99	<99	<99	<108	473
February 2004													
LIBLAKE	4064113	31	<111	<111	<111	<111	<111	<111	<111	<111	<111	<122	<111
KaiserEff	4064105	1	<112	<112	<112	<112	<112	<112	<112	<112	<112	<123	<112
KaiserEff Rep.	4064106	1	<106	<106	<106	<106	<106	<106	<106	<106	<106	<116	<106
KaiserEff	4064107	1	<109	<109	<109	<109	<109	<109	<109	<109	<109	<119	<109
KaiserLag	4064110	5	<106	422	2,580	3,720	647 J	<106	<106	<106	<106	<117	7,370
KaiserFilt	4064109	1	<109	<109	307	125 J	<109	<109	<109	<109	<109	<120	432 J
Inland Emp	4064111	9	<109	<109	<109	<109	<109	<109	<109	<109	<109	<120	<109
SPOKWWTP	4064112	10	<108	<108	<108	123	259	122	<108	<108	<108	<119	504
April 2004													
LIBLAKE	4188205	43	999 NJ	<112	<112	265	<112	<112	<112	<112	<112	<123	1,260 NJ
KaiserEff	4188198	1	<112	<112	<112	<112	<112	<112	<112	<112	<112	<112	<112
KaiserEff	4188199	1	<107	<107	<107	<107	<107	<107	<107	<107	<107	<107	<107
KaiserLag	4188202	1	<104	112 J	<104	<104	<104	<104	<104	<104	<104	<104	112 J
KaiserFilt	4188201	1	<106	<106	<106	<106	<106	<106	<106	<106	<106	<106	<106
Inland Emp	4188203	2	<112	<112	<112	<112	<112	<112	<112	<112	<112	<112	<112
SPOKWWTP	4188204	5	<102	<102	<102	342	588	329	<102	<102	<102	<113	1,260
SPOKWWTP Rep.	4188206	6	865 NJ	<107	<107	360	826	358	<107	<107	<107	<117	2,410 NJ

Detected values are in green highlight.
<: The analyte was not detected at or above the reported result (U or UJ).
NJ: There is evidence that the analyte is present. The associated numerical result is an estimate.
J: The analyte was positively identified. The associated numerical value is an estimate.

PCBs in Stormwater Discharged to the Spokane River

Stormwater sampling during the 2003-04 PCB source assessment study was conducted by City of Spokane personnel during one runoff event on June 10, 2004. Only four locations were sampled, although the sampling plan proposed more sites and storm events. Samples were collected from manholes nearest the outfalls draining the particular stormwater conveyance systems.

Due to the limited data from 2004, a second and larger set of stormwater samples was collected in the spring of 2007 by Parsons, a consultant hired by Ecology. Locations are shown in Figure 14. Results from both the 2004 and 2007 efforts are presented in Tables 22 to 26. The location IDs that correspond to the location descriptions were shown in Tables 11 and 12.

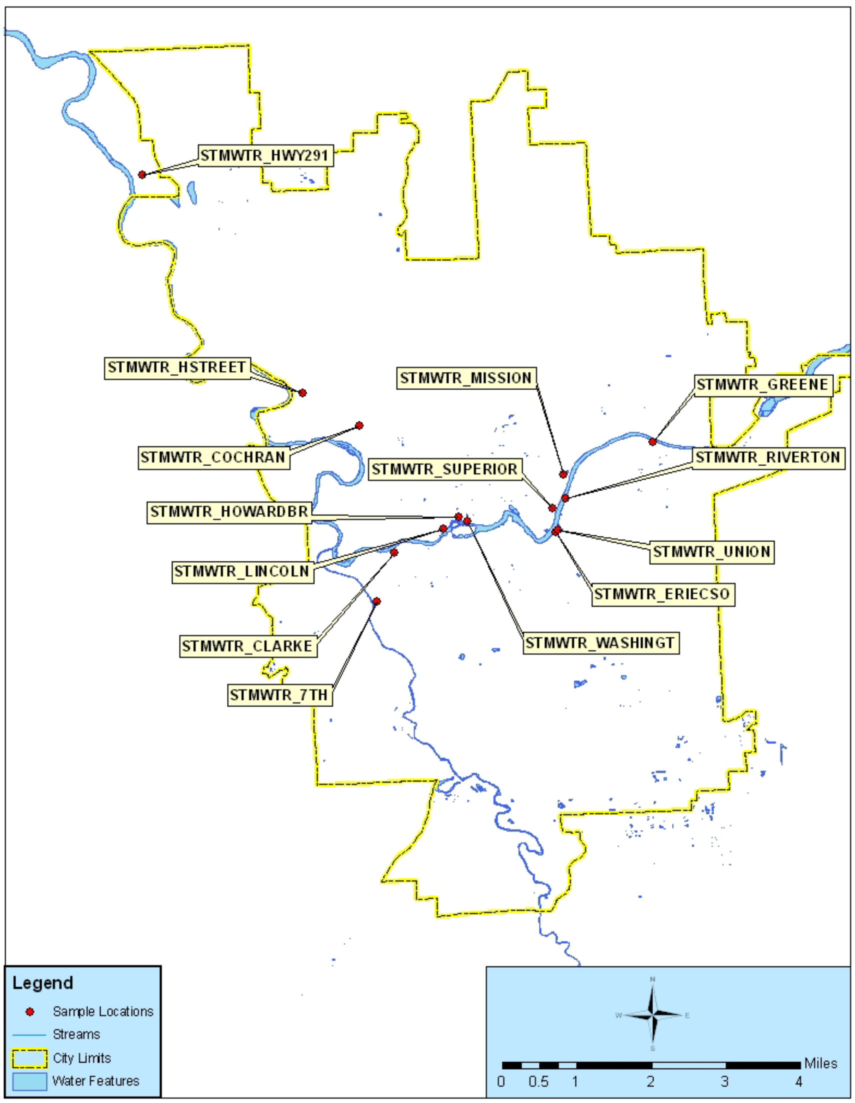


Figure 14. Stormwater Basins in the City of Spokane Sampled for PCBs During 2007 by Parsons.

Table 22. June 10, 2004 Stormwater PCB Concentrations Grouped by Homologues (pg/l).

Location ID*	Sample Number	TSS (mg/L)	1-Cl	2-Cl	3-Cl	4-Cl	5-Cl	6-Cl	7-Cl	8-Cl	9-Cl	10-Cl	Total PCBs
Stmwtr_Mission (STMMISSBR)	4254001	58	<117	<117	117	5,490	28,800 J	19,200	6,660	1,600	283	254	62,400 J
Stmwtr_ErioeCSO (CSO 34)	4254000	126	<111	<111	685	3,120	10,200	28,500	32,400	7,800	678	<123	83,400
Stmwtr_Superior (STMSUPOUT)	4254003	26	<102	<102	<102	843	1,920	1,270	749	120	<102	<112	4,900
Stmwtr_Washingt (STMWASHBR)	4254002	91	<113	<113	285	2,560	8,380 J	5,290 J	2,530	690	198	<124	19,900 J

Detected values are in green highlight.
* Location ID in parentheses is presented for access to data in EIM. The Location IDs correspond to Table 12, which is the ID given for the 2007 stormwater sampling.
<: The analyte was not detected at or above the reported result (U or UJ).
J: The analyte was positively identified. The associated numerical value is an estimate.

Table 23. May 2, 2007 Stormwater PCB Concentrations Grouped by Homologues (pg/l).

Location ID*	Sample ID	TSS (mg/L)	1-Cl	2-Cl	3-Cl	4-Cl	5-Cl	6-Cl	7-Cl	8-Cl	9-Cl	10-Cl	Total PCBs
HWY291	07184210	19	76	78	45	483 J	572	408	446	70	<20	<20	2180 J
7TH (CSO 26)	07184211	22	<80	<80	<80	<80	713 J	575	120	<80	<80	<80	1410 J
HSTREET (CSO 7)	07184212	63	<20	120	135	855 J	1,380	973	768	190	54	48	4520 J
COCHRAN	07184213	155	85	578	953	2,430 J	5,770	4,440	2,890	813	293	<20	18,250 J
LINCOLN	07184214	8	<20	<20	88	622 J	1,130	556	315	56	44	<20	2810 J
CLARKE (CSO 24A)	07184215	4	<80	<80	<80	<80	<80	<80	<80	<80	<80	<80	<80[1]
HOWARDBR	07184216	7	<20	102	194	849 J	734	408	309	29	27	42	2700 J
UNION	07184217	67	75	1,960	8,500	21,990	27,660	39,350	42,050	24,860	1,570	160	168,160
RIVERTON	07184218	27	23	336	919	6,570	17,200	10,050	6,050	1,900	99	<20	43,140
WASHINGT	07184221	26	57	295	408	1,700 J	2,800	1,330	1,110	514	82	<20	8,290 J
SUPERIOR	07184222	43	61	440	859	4,970 J	21,340	10,830	2,620	996	84	33	42,230 J
ERIECSO (CSO34)	07184223	40	115	2,960	13,650	29,140	48,120	85,070	78,890	20,190	2,000	296	280,430
MISSION	07184224	34	<100	319 J	381 J	2,990 J	9,720	6,690	2,220	452	<100	<100	22,770 J
SUPERIOR-Replicate	07184225	306	<100	342 J	527	2,350	9,250	6,670	1,410	690	<100	<100	21,230 J
SUPERIOR-Replicate	07184226	27	65	496	971	2,620	6,720	5,310	1,740	1,310	40	<20	19,260

Detected values are in green highlight.
*: In EIM these Locations IDs have the prefix STMWTR_; CSO number in parentheses is not part of the EIM Location ID.
[1]: The Clarke 07184215 Total PCB was revised from 0.062 to <80, post publication in the 2007 Parsons Report. The online report reflects the change.
<: The analyte was not detected at or above the reported result (U or UJ).
J: The analyte was positively identified. The associated numerical value is an estimate.

Table 24. May 21, 2007 Stormwater PCB Concentrations Grouped by Homologues (pg/l).

Location ID*	Sample ID	TSS (mg/L)	1-Cl	2-Cl	3-Cl	4-Cl	5-Cl	6-Cl	7-Cl	8-Cl	9-Cl	10-Cl	Total PCBs
HWY291	07214210	8	110	105 J	<40	66 J	231	<40	<40	<40	<40	<40	512 J
7TH (CSO 26)	07214211	7	<40	158	51 J	296	342	144	<40	<40	<40	<40	991
HSTREET (CSO 7)	07214212	41	<40	137 J	<40	315 J	801 J	514	305	108	<40	<40	2,179 J
COCHRAN	07214213	12	43 J	135 J	<40	125 J	275 J	95 J	46 J	<40	<40	<40	719 J
LINCOLN	07214214	3	<40	164 J	<40	132 J	353 J	187	<40	<40	<40	<40	836 J
CLARKE (CSO 24A)	07214215	2	<40	101 J	<40	124	<40	<40	<40	<40	<40	<40	225 J
HOWARDBR	07214216	3	<40	122 J	57 J	302 J	317 J	42 J	<40	<40	<40	<40	839 J
UNION	07214217	18	142	373 J	645	1,795 J	3,006 J	4,325	4,631	1,121	62 J	<40	16,099 J
RIVERTON	07214218	14	52 J	<40	47 J	422 J	856 J	997	1,511	356	<40	<40	4,240 J
GREENE	07214219	38	54 J	233 J	828	2,367 J	3,033 J	2,254	2,238	403	<40	<40	11,409 J
WASHINGT	07214221	11	159	132 J	<40	<40	395 J	247	49 J	<40	<40	<40	981 J
WASHINGT-Replicate	07214225	8	108	136 J	<40	169 J	396 J	132	<40	<40	<40	<40	939 J
WASHINGT-Replicate	07214226	9	74 J	80 J	<40	156 J	402 J	239	65 J	<40	<40	<40	1,017 J
SUPERIOR	07214222		196	110 J	<40	155 J	304 J	202	185	<40	<40	<40	1,152 J

Detected values are in green highlight.
*: In EIM these Locations IDs have the prefix STMWTR_
<: The analyte was not detected at or above the reported result (U or UJ).
J: The analyte was positively identified. The associated numerical value is an estimate.

Table 25. June 5, 2007 Stormwater PCB Concentrations Grouped by Homologues (pg/l).

Location ID*	Sample ID	TSS (mg/L)	1-Cl	2-Cl	3-Cl	4-Cl	5-Cl	6-Cl	7-Cl	8-Cl	9-Cl	10-Cl	Total PCBs
HWY291	07234710	6	<40	<40	<40	<40	98 J	143	<40	<40	<40	<40	241 J
7TH (CSO 26)	07234711	26	150	121	91 J	702 J	2,708 J	2,382	1,059	382	64 J	48 J	7,707 J
HSTREET (CSO 7)	07234712	46	<40	<40	<40	<40	422 J	266 J	62 J	<40	<40	<40	749 J
COCHRAN	07234713	298	65 J	552	724	2,458 J	5,257	6,301	2,535	1,078	518	110	19,598 J
LINCOLN	07234714	51	<40	215	378	1,187 J	3,163 J	2,818	852	495	255	61 J	9,423 J
CLARKE (CSO 24A)	07234715	92	<40	108	72 J	452 J	1,725 J	1,628	591	196	94 J	<40	4,867 J
HOWARD BR	07234716	67	<40	605	4,404	4,662	2,366 J	1,722	773	210	111	86 J	14,940 J
HOWARD BR-Replicate	07234725	63	<40	528	4,393	4,158	2,549 J	1,222	627	121	122	93 J	13,813 J
HOWARDBR-Replicate	07234726	46	<40	433	3,591	3,302	1,760 J	1,410	566	130	79 J	123	11,393 J
UNION	07234717	65	49 J	511	2,387	5,037	12,488	39,653	36,975	9,056	602	44 J	106,802
RIVERTON	07234718	82	<40	200	500	1,465 J	3,824 J	6,735	5,309	1,222	124	<40	19,380 J
GREENE	07234719	117	<40	295	1,770	3,631	5,599	9,275	5,463	1,315	232	43	27,622
WASHINGT	07234721	158	<40	216	404	1,947 J	2,726 J	2,489	681	318	171	80 J	9,031 J
SUPERIOR	07234222	55	<40	116	109	742 J	1,451 J	1,622	593	227	53 J	<40	4,912 J
ERIECSO (CSO34)	07234223	159	62 J	582	2,094	4,987	10,768	28,081	19,456	6,027	568	62 J	72,686
MISSION	07234224	30	<40	120	152	897 J	3,131 J	3,593	1,884	446	90 J	<40	10,311 J

Detected values are in green highlight.
*: In EIM these Locations IDs have the prefix STMWTR_
<: The analyte was not detected at or above the reported result (U or UJ).
J: The analyte was positively identified. The associated numerical value is an estimate.

Summary statistics for PCB concentrations in City of Spokane stormwater samples from 2004 and 2007 are shown in Table 26. Stormwater PCB concentrations ranged over two orders of magnitude in both data sets from 2004 and 2007. Individual total PCB concentrations varied widely from <80 to 280,000 pg/l in the 2007 Parsons study, and from 4,900 to 83,400 pg/l in 2004.

Table 26. Summary Statistics for Total PCB Concentrations in Spokane Stormwater (pg/l).

Statistic	Stormwater Sampling	
	Ecology in 2004	Parsons in 2007
minimum	4,900	240
10th	9,400	777
25th	16,150	1,118
mean	42,650	23,023
median	41,150	8,000
75th	67,650	19,290
90th	77,100	42,867
95th	80,250	101,684
maximum	83,400	280,430

Parsons provided an in-depth review of the 2007 data in their report (Parsons, 2007). They concluded that:

- Stormwater basins CSO 34 and Union Street showed the highest average concentrations for the three events.
- Total PCB concentrations showed a direct correlation with TSS.
- Sources of PCBs are similar in the stormwater systems, with the exception of the Howard Bridge site. The greater relative abundance of less chlorinated PCBs at Howard Bridge may indicate the presence of a different source.

Post publication of the Parsons report, Union Street was found to drain to the CSO34 (Erie Street) system. Their relative drainage areas are 109 and 1,951 acres, respectively. Thus, Union Street, at <6% of the CSO 34 area, may be largely responsible for the high PCB levels detected at CSO 34.

The Clarke 07184215 total PCB result was revised post publication of the Parsons (2007) report from 0.062 to <80 pg/l.

A wide range of PCB homologues was detected in Spokane stormwater (Tables 22-25) and in particulate samples from the Spokane River (Table 19). A similar homologue range was seen in Spokane River sediment samples (see Table 30). In contrast, a relatively narrow group of dichloro through pentachlorobiphenyl homologues was found in industrial and municipal effluents (Table 21). This finding, coupled with the loading analysis that follows, supports a conclusion that stormwater is a significant PCB source to the Spokane River.

Stormwater Discharges

Streamflow data were not collected during stormwater sampling. Therefore the discharge was estimated using calculations based on rainfall. The average annual stormwater discharge predicted by the Simple Method (www.stormwatercenter.net) was calculated by Parsons (2007). Briefly, the Simple Method uses the equation:

Equation 4. $R = P * Pj * Rv$

where R is annual runoff (inches), P is annual rainfall (inches), Pj is the fraction of annual rainfall events that produce runoff (assumed 0.9), and Rv is a runoff coefficient.

In this method, the runoff coefficient is calculated based on impervious area in the subwatershed (Ia). Watershed imperviousness is a reasonable predictor of Rv (Schueler, 1987), with the relationship best defined as:

Equation 5. $Rv=0.05+0.9Ia$

Geographical data were provided by the City of Spokane Wastewater Management Department. Annual rainfall was estimated to be 18 inches in Spokane, based on data from Ecology's Eastern Washington Stormwater Manual Precipitation Maps (Ecology, 2004 www.ecy.wa.gov/biblio/0410076maps.html). A value of 0.9 was used as the fraction of runoff.

The first step for developing flow estimates using the Simple Method was to determine the area draining to each of the sampling locations. To do so, a shapefile of stormwater boundaries provided by the City of Spokane was merged with the shapefile of areas contributing stormwater to the various CSOs (also provided by the City of Spokane) in a geographic information system. Figure 15 presents the combined stormwater-CSO boundaries for the entire city.

The second step was to determine the impervious areas. Pervious surfaces were determined in each drainage area based on 2007 geographic data. The total impervious area contributing was calculated as the sum of transportation and off-street impervious areas. Percent impervious for all the stormwater basins in the City of Spokane ranged from roughly 12 to 54% for the basins with any development (Parsons, 2007). This stormwater assessment did not take the Census-defined urban areas nor the Urban Growth boundary into account. The Spokane city limits were defined by the 2005 city boundary.

The total PCB average for each sampling station, as well as the calculated impervious fraction, area, and runoff, are shown in Table 27.

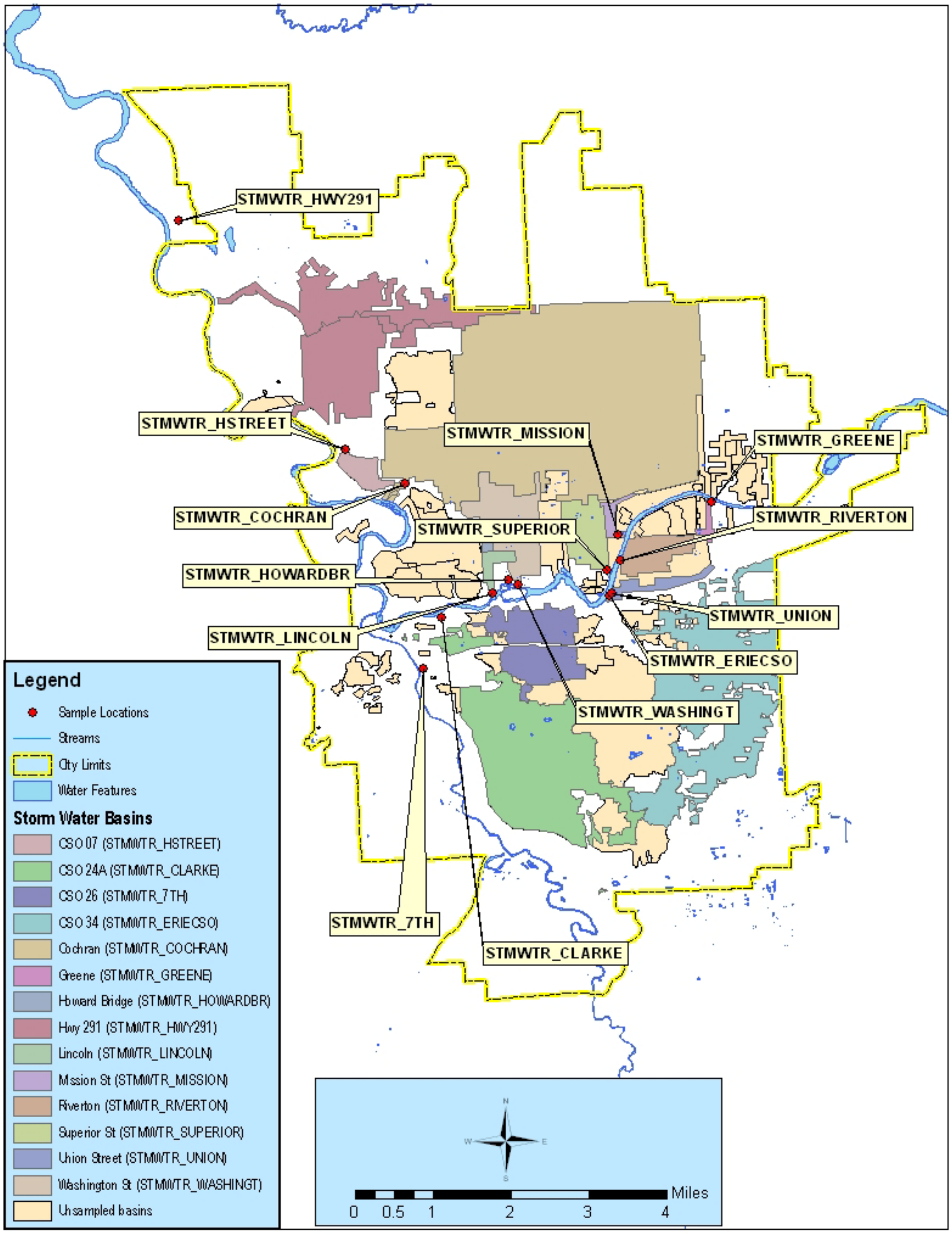


Figure 15. Stormwater Basins in the City of Spokane, Parsons, (2007).

Table 27. Total PCB Results, Impervious Fraction, and Runoff for Spokane Stormwater Basins.

Location_ID[1]	Total PCB (ng/L)[2]	Impervious Fraction	Drainage Area (acre)	Annual Runoff Volume (in)[3]
Sampled Stormwater Basins (High CSO Load Scenario)				
Above Monroe St Dam				
GREENE	19.5	0.365	34	6.1
MISSION	16.5	0.277	55	4.8
RIVERTON	22.3	0.217	233	4
SUPERIOR	17.8	0.376	294	6.3
UNION	97	0.323	109	5.5
ERIECSO (CSO 34)	177	0.24	2,060[4]	4.3
WASHINGT	4.05	0.417	465	6.9
HOWARDBR	8.74	0.407	57	6.7
Below Monroe St Dam				
LINCOLN	4.36	0.544	69	8.7
CLARKE (CSO 24A)	2.56	0.267	1,863	4.7
7TH (CSO 26)	3.38	0.439	609	7.2
COCHRAN	12.9	0.274	5,164	4.8
HSTREET (CSO 7)	2.49	0.247	121	4.4
HWY291	0.978	0.248	1,578	4.4
Totals			**12602**	**79**
29 Un-Sampled Stormwater Basins (Low CSO Load Scenario)				
Average Conc.	23			
Totals		**varied**	**4652**	**147**

Green shading represents CSO basins.
[1] In EIM these Locations IDs have the prefix STMWTR_; CSO number in parentheses is not part of the EIM Location ID.
[2] Average of all the samples collected in the 2007 Parsons study; the PCB average was updated by Ecology.
[3] Calculated for stormwater basins only, using Equations (6) and (7) and an annual rainfall amount of 18 inches.
[4] Includes Union area (109 acres).

PCB stormwater concentrations were found to be related to TSS concentrations in the Parsons study. TSS concentrations were substantial in stormwater (2-298 mg/L, Tables 22-25). Based on the high octanol-water partitioning coefficients (K_{ow}) for PCBs and the high TSS concentrations, it can be assumed that most of the PCBs were adsorbed to the solids fraction in stormwater. Approximately 85%-95% of the PCBs were estimated to be bound to the solid phase (i.e., attached to the suspended sediment) when the partitioning formula Eq. 3, described previously, was applied and an organic carbon fraction of 0.05 used. If this is the case, the suspended sediment carried in stormwater would have average dry weight t-PCB concentrations ranging from approximately 150 to 1,000 ng/g, or about two to 15 times the levels seen in suspended particulate matter in the Spokane River at Ninemile.

PCBs in Spokane River Bottom Sediments

Bottom sediment sampling site locations and dates are shown in Table 28. These sites were selected to investigate the possibility of PCB enriched sediments behind Monroe St. Dam, assess the longitudinal PCB concentration gradient in Lake Spokane, evaluate the potential of the un-surveyed Little Spokane River as a significant PCB source, and measure PCB concentrations in previously sampled Spokane River reaches downstream of Lake Spokane.

Table 28. Bottom Sediment Locations and Sampling Dates.

Station Location	Sample Name	RM	Dates
Spokane River above Monroe St.	MonroeSed	74.8	4/14/04
Upper Lake Spokane	LongLkUp	54.3	5/11/04
Middle Lake Spokane	LongLkMid	44.3	11/4/03
Lower Lake Spokane	LONGLKLOW	38.4	10/2/03 11/4/03 4/13/04
Spokane River above Little Falls Dam	Littlefls	29.9	11/4/03
Spokane River at Porcupine Bay	SPOK-1	11.3	11/06/03
Little Spokane River above SR291	LitlSpokSed	1.1	12/10/03
Buffalo Lake	BUFFALO REF	--	11/5/03

Due to the lack of bulk fine-grained deposits in the Spokane River, sampling was limited to a smaller number of sites than originally planned. Sampling the fine-grained sediment deposit behind Upriver Dam was deemed unnecessary due to the intensive investigation and cleanup being completed at this site.

Grain size composition and PCBs in surficial (top 2 cm) sediments from various Spokane River locations and one reference site (Buffalo Lake) are shown in Tables 29 and 30, respectively.

Table 29. Grain Size in Bottom Sediments (%).

Sample Name	Sample Number	Sand	Gravel	Silt	Clay
MonroeSed	04168149	47.1	52	0.8	0.0
LongLkUp	04208147	22	0.1	73.6	4.3
LongLkMid	03454111	3.6	0	76.3	20.2
LONGLKLOW	03454112/4*	7.0	0.1	59.1	34.0
Littlefls	03454113	88.2	0	9.4	2.3
SPOK-1	03458100	9.7	0	66.5	23.8
LitlSpokSed	03504060	84	0.2	13	2.8
BUFFALO REF	03458103	23.3	0.3	25.4	50.9

*Mean of replicate analysis.

Table 30. PCB Concentrations Grouped by Homologues in Surficial (top 2 cm) Bottom Sediments (ng/g, dw).

Station Name	Sample Number	TOC (%)	1-Cl	2-Cl	3-Cl	4-Cl	5-Cl	6-Cl	7-Cl	8-Cl	9-Cl	10-Cl	Total PCBs
MonroeSed	4168149	0.36	<0.01	<0.01	0.04	0.15	3.00J	1.79	0.90	0.24J	0.05J	<0.02	6.17J
LongLkUp	4208147	2.8	0.17J	0.90	5.99	16.1	13.1J	8.52J	3.50	1.06	0.23	0.12	49.7J
LongLkMid	3454111	2.98	<0.24	0.30	3.05	7.31	5.54	5.23	1.76	0.86	0.27	0.08	24.4
LONGLKLOW	3454112/4*	2.81	0.09J	0.37	2.80	8.49	6.89	4.22	2.23	0.94	0.22	0.08	26.3
Littlefls	3454113	0.61	<0.05	0.10	0.24	0.52	0.62	0.35	0.05	<0.05	<0.05	<0.05	1.90
SPOK-1	3458100-S	1.71	<0.05	0.20	0.72	3.61	3.08	1.59	0.89	0.28	0.07	<0.05	10.4
LitlSpokSed	3504060	0.85	<0.05	<0.05	0.06	0.16	0.31	0.24	0.25	0.75	0.30	<0.05	2.06
BUFFALO REF	3458103-S	8.24	<0.05	0.06	0.07	0.30	0.82	0.81	0.30	0.12	0.23	0.16	2.88

*Mean of replicate analysis.
Detected values are in green highlight.
<: The analyte was not detected at or above the reported result.
J: The analyte was positively identified. The associated numerical value is an estimate.

Concentrations ranged from 50 ng/g total PCB at upper Lake Spokane to 1.9 ng/g at Little Falls. Upper Lake Spokane sediments have total PCB concentrations similar to suspended particulate matter concentrations at Ninemile, suggesting that this material is deposited in this reach. Surficial sediment PCB levels from the lower and middle reaches of Lake Spokane were one-half those in the upper reach.

The river sediments at Monroe St. had low PCB concentrations (6.2 ng/g total PCB) as did the Little Spokane River (2.1 ng/g) and Little Falls. The low concentrations probably reflected a lack of organic carbon-enriched fine material in these reaches. When PCB concentrations among sites were compared on an organic carbon normalized basis, the Lake Spokane stations retained the same relative PCB levels, Little Falls and the Little Spokane River were comparatively low, and Monroe St. total PCB concentrations were as high as those from upper Lake Spokane (Figure 16).

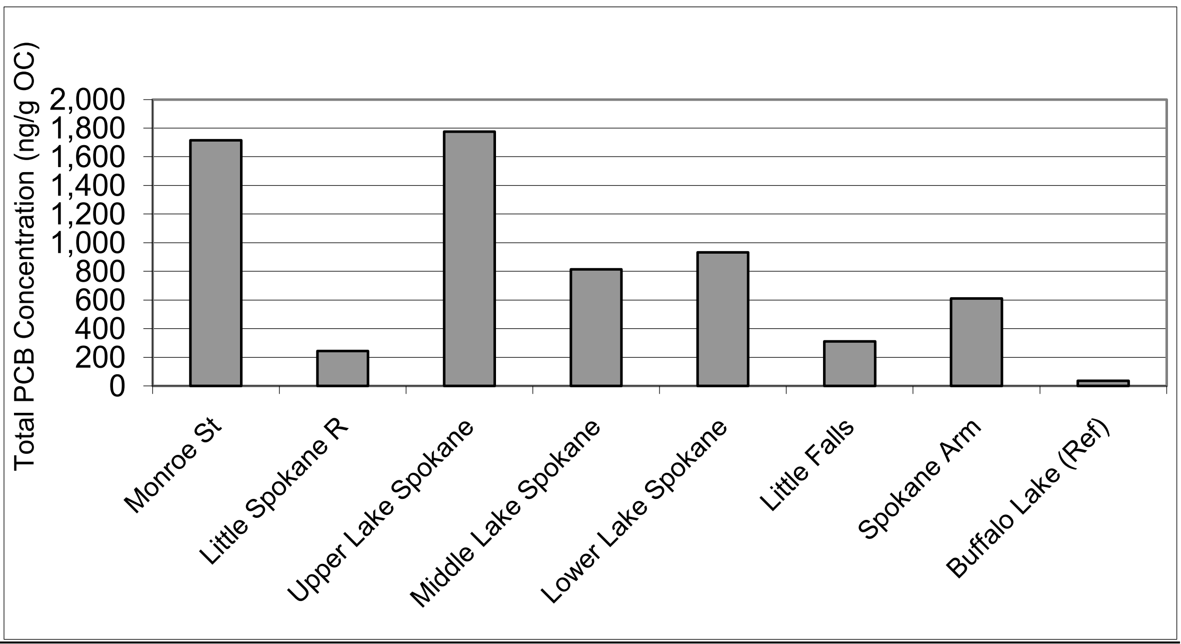


Figure 16. Surficial (Top 2 cm) Sediment PCB Concentrations in Spokane River and Little Spokane River Sediments Normalized to Organic Carbon (Buffalo Lake is a reference location).

TOC-normalized total PCB concentrations at Monroe St. and Upper Lake Spokane sediments were elevated 50 times the reference sediment from Buffalo Lake. Middle and lower Lake Spokane sediments were one-half that elevation. Little Spokane River and Little Falls sediments were more than nine times above PCBs in the reference sediments, while Spokane Arm (Porcupine Bay) levels were 18 times higher.

Temporal trends in sediment PCBs are difficult to establish due to the higher reporting limits in the Aroclor analysis of previous studies. For instance, Johnson and Norton (2001) found TOC-normalized total PCB concentrations of 400, 740, and 3,800 ng/g organic carbon at upper, middle, and lower Lake Spokane, respectively, but few Aroclors were detected and reporting limits were often >10 ng/g. In 1993, Ecology found 1,400 ng/g organic carbon at lower Lake

Spokane, using essentially the same analysis and near the same location (Ecology, 1995). Spokane Arm (Porcupine Bay) sediments from the same survey showed 770 ng total PCB/g organic carbon, representing the only other comparable data for sediments.

To more closely examine the historical record of PCB deposition in Spokane River sediments, PCBs were analyzed at various depths in a 30-cm core collected in upper Lake Spokane and in a 44-cm core from lower Lake Spokane. Table 31 shows total PCB concentrations at various depths in each core. Figures 17 and 18 show the chronology of PCB deposition based on radionuclide (^{210}Pb) decay in sediments (Appleby and Oldenfield, 1978).

Table 31. Total PCB Concentrations in Sediment Cores from Upper and Lower Lake Spokane (ng/g, dw).

Station/Sample ID	Depth (cm)	TOC (%)	Total PCB
LONGUP2			
04268382	0-1	2.82	8
04268383	1-2	2.38	14
04268384	3-4	2.27	16
04268385	5-6	1.81	16
04268386	7-8	1.94	19
04268387	9-10	1.79	33
04268388	11-12	1.85	32
04268389	14-15	1.85	28
04268390	24-25	2.01	51
04434079	28-29	1.87	32
04268391	29-30	2.58	30
LONGLOW2			
04268372	0-1	3.08	28
04268373	1-2	2.76	75
04268374	3-4	2.83	42
04268375	5-6	2.48	40
04268376	7-8	2.41	27
04268377	9-10	2.36	32
04268378	11-12	2.69	54
04268379	14-15	2.74	59
04268380	24-25	2.70	233
04268381	34-35	2.70	1,000
04434078	41-42	2.70	701

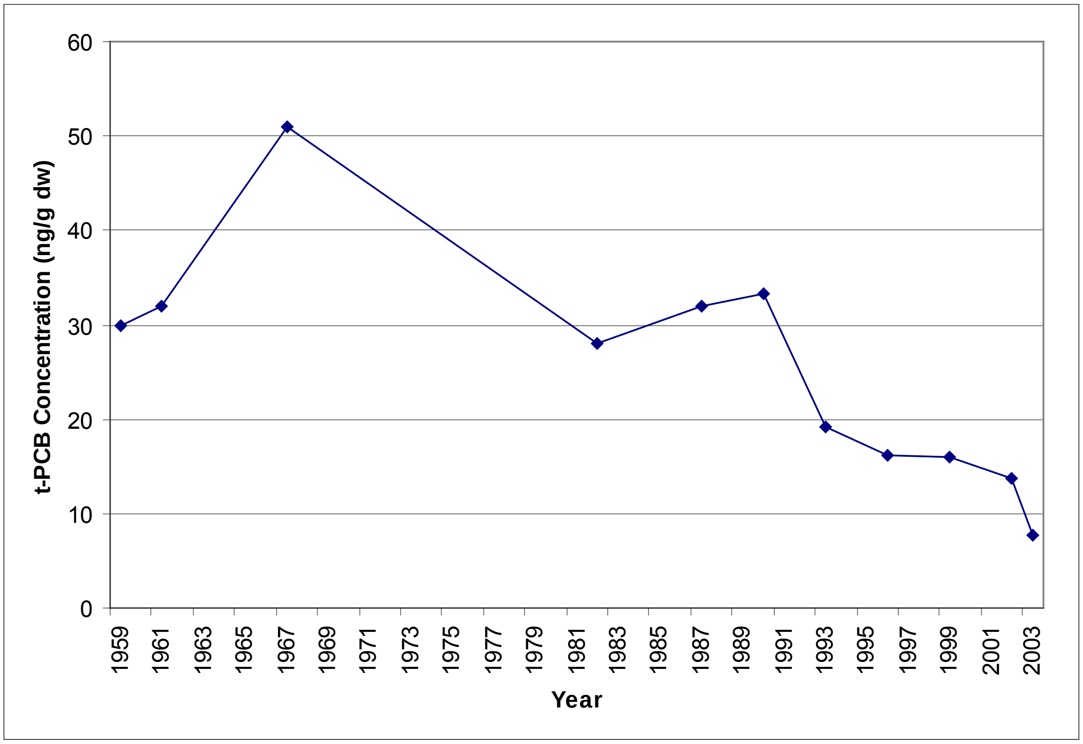


Figure 17. Chronology of PCB Concentrations in Upper Lake Spokane Sediments.

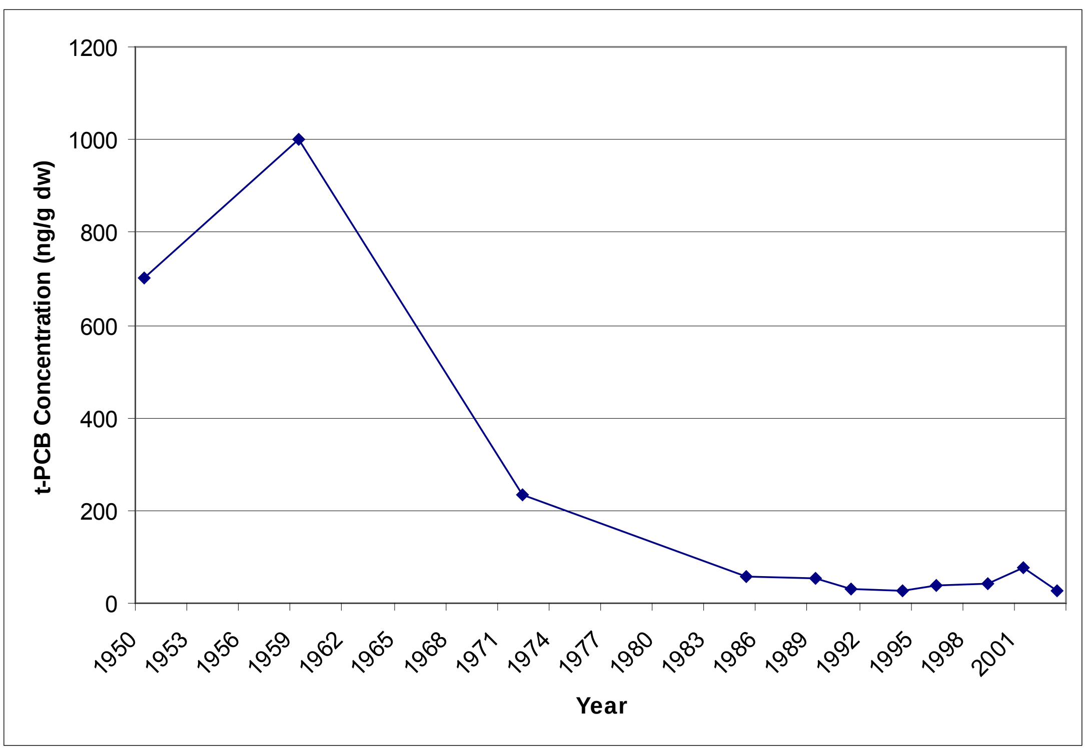


Figure 18. Chronology of PCB Concentrations in Lower Lake Spokane Sediments.

The sediment core from upper Lake Spokane was not as deep as desired due to coarser material preventing maximum corer penetration, and therefore PCB history could only be traced to circa 1959. The PCB profile showed a declining trend from 1959 to 2003, with a 1967 peak (51 ng/g), nearly coinciding with peak domestic PCB production in 1970.

The shape of the PCB profile from lower Lake Spokane had similarities to the upper lake. The peak occurred earlier with 1,000 ng/g circa 1959, but no horizons deposited between 1959 and 1972 were analyzed for PCBs, raising the possibility that the peak PCB concentration in this core was more than 1,000 ng/g and may have occurred later than 1959. PCB concentrations in sediment deposits have leveled off significantly in the past two decades, a pattern that has been observed at other locations in Washington (e.g., Serdar, 2003).

Cores from upper and lower Lake Spokane differ vastly in PCB levels, with peak years showing at least a 30-fold higher concentration at the lower lake. Lower Lake Spokane had post-peak total PCB concentrations 2-5 times higher than those deposited the same years in the upper lake, except during the early 1990s when PCB levels were nearly identical.

The surficial sediments and those normalized to TOC show upper Lake Spokane has higher PCBs. However, the sediment core samples and other studies indicate lower Lake Spokane historically had higher PCBs. This most likely has to do with the complex sedimentation history of the Lake Spokane Dam reservoir and sedimentation patterns from the tributaries to the lake.

The differences in PCB concentrations between upper and lower Lake Spokane and the apparent variability in PCB concentrations in upper lake sediments indicate that these locations receive sediments at proportionally different rates over time and possibly from different sources. The high level of PCBs historically deposited in the lower lake most likely originate from PCB contamination sources in and around Spokane, whereas the upper lake sediments are probably diluted with comparatively clean sediments from the Little Spokane River and Latah Creek, the latter providing large volumes of clean sediment (Johnson and Norton, 2001; SCCD, 2002).

The ^{210}Pb profile in the lower lake shows a steady input of newly formed material and little perturbation of sediments, while upper lake sediments appear to contain older material near the surface, presumably delivered from Little Spokane River and Latah Creek, and an inconsistent decay profile suggesting physical disturbance. Future analysis of upper lake sediments should be conducted with caution and consideration for the dynamics of sedimentation in this reach.

PCBs in Spokane River Fish

2003-2004

As part of the PCB source assessment, several species of fish were collected from multiple locations in the Spokane River from the state line through Lake Spokane. Table 32 shows concentrations of PCBs in rainbow trout fillets and in gut contents. Male rainbow trout from Plante Ferry had a somewhat higher PCB concentration than females, even though female fish were larger on average (391 vs. 363 mm). One possible explanation for the difference in concentrations at this location is that female fish may have mobilized PCBs along with lipids to egg production, since all female trout from this location were gravid. However, lipid content was nearly identical between sexes, suggesting other factors at play. Ninemile rainbow trout had slightly lower PCB concentrations than Plante Ferry possibly due to the smaller length (311 vs. 377 mm), exposure history, or lower lipids (1.3 vs. 1.7%) on average.

The Ninemile rainbow trout, having been analyzed individually, offer an opportunity to examine some of the factors determining PCB levels in tissue for fish collected from this location. Upon initial inspection, it appears that sex differences play a large role in PCB concentrations since females have twice the average PCB levels compared to males. However, the median age of the female fish was three years versus one year for the male fish, and the females were 20% longer on average. Another possible factor is the origin of the specimens; the larger females were all wild fish while the majority of male specimens were hatchery-raised based on the pattern of scale checking (John Sneva, WDFW, written communication). Differences in PCB levels of wild versus hatchery fish also may be due to foraging habits or prey selection.

PCB concentrations in rainbow trout gut contents were approximately 15%-30% those in tissue. Many of the specimens collected at both Plante Ferry and Ninemile were engorged with filamentous plant material. This material holds insects and other aquatic organisms, which are digested while the plant material remains undigested. Aquatic organisms extracted from Ninemile trout stomachs were mostly Corixidae (water boatman) adults, Chironomidae larvae, and Trichoptera larvae (probably Hydropsychidae). The gut contents of Plante Ferry rainbow trout were not examined closely, but casual observation suggested that contents were similar to Ninemile specimens; and PCB concentrations were similar as well. Crayfish or crayfish parts were also observed in the guts of some Plante Ferry trout.

Table 33 shows congener and total PCB concentrations (sum of detected congeners) in suckers analyzed whole and in gut contents. Crayfish from the Upriver Dam cleanup site are also included in Table 33. Suckers were composited by size to assess growth dilution as a potential factor in PCB concentrations. Growth dilution occurs when a fish grows faster than the accumulation rate of the contaminant of concern, lowering the contaminant concentration as the fish size increases.

Table 32. 2003-2004 PCB Concentrations in Rainbow Trout from Plante Ferry and Ninemile (ng/g, ww)

Station-Tissue	Sample ID	Composite	Sex	Lipid	1-Cl	2-Cl	3-Cl	4-Cl	5-Cl	6-Cl	7-Cl	8-Cl	9-Cl	10-Cl	Total PCB
Fillet															
PLANTE-F	4188308	Y	M	1.7%	0.004N	0.03	0.14	7.15	13.4	9.08J	10.2J	0.83	0.15J	0.02	40.9 J
	4188309	Y	F	1.7%	0.01J	0.06J	0.09	5.13J	6.35J	9.97J	5.82J	0.81	0.11	0.02	28.4 J
														mean=	**34.7**
Ninemile (WSTMP)[2]	084281	N	M	1.5%	<0.02	0.02	0.14	1.81	3.29	3.08	1.12	0.25	<0.02	<0.02	9.7
	084282/308 *	N	F	2.7%	0.02	0.03	1.01	6.45	19.8	20.4	6.45	1.73	0.16	0.02	56.0
	084283	N	M	1.3%	<0.02	0.03	0.13	2.35	5.04	4.25	1.41	0.26	0.03	<0.02	13.5
	084284	N	M	1.9%	<0.02	0.03	0.72	4.96	13.1	10.3	4.44	0.83	0.08	<0.02	34.4
	084285	N	F	1.1%	<0.02	<0.02	0.08	4.58	16.9	19.4	7.74	1.88	0.30	0.04	50.9
	084286	N	M	1.0%	<0.02	0.02	0.12	2.18	4.43	3.65	1.04	0.14	0.02	<0.02	11.6
	084287	N	M	0.4%	<0.03	<0.03	0.53	1.73	4.87	3.68	1.24	0.30	<0.03	<0.03	12.3
	084288	N	M	1.9%	<0.03	0.04	1.03	3.09	6.17	4.86	1.66	0.40	<0.03	<0.03	17.3
	084289	N	F	0.7%	<0.02	0.02	0.61	3.80	12.8	15.4	7.06	2.44	0.19	0.03J	42.4
	084290	N	M	3.3%	<0.02	0.04	1.70	9.48	31.2	19.0	10.7	2.20	0.15	<0.02	74.5
	084291	N	F	2.5%	<0.02	0.04	1.36	7.33	19.5	16.3	5.95	1.25	0.16	0.03	51.9
	084292	N	M	2.0%	<0.02	0.03	1.13	6.27	17.0	13.6	5.56	1.04	0.12	<0.02	44.8
	084293	N	M	1.8%	<0.02	0.03	0.39	3.75	9.98	8.96	3.23	0.65	0.09	<0.02	27.1
	084294	N	M	1.0%	<0.02	0.03	0.14	1.86	4.00	2.65	0.79	0.23	<0.02	<0.02	9.7
	084295	N	M	0.6%	<0.02	0.03	0.14	2.70	4.91	4.59	1.94	0.27	0.03	<0.02	14.6
	084296	N	M	0.4%	<0.02	0.03	0.11	2.20	4.18	2.72	1.16	0.25	0.02	<0.02	10.7
	084298	N	M	0.9%	<0.02	0.03	0.72	2.55	4.90	4.94	1.94	0.46	0.03	<0.02	15.6
	084299	N	M	0.2%	<0.02	0.03	0.07	2.62	7.16	4.67	1.84	0.39	0.02	<0.02	16.8
	084301	N	M	1.5%	<0.02	0.03	0.89	5.72	13.6	15.7	5.37	1.59	0.16	0.02	43.2
	084302	N	M	0.8%	<0.02	0.03	0.77	3.04	6.48	6.48	2.76	0.53	0.03	<0.02	20.1
	084303	N	F	0.9%	<0.02	0.03	0.60	3.29	9.30	10.7	3.28	1.35	0.11	0.02	28.7
	084304	N	M	0.3%	<0.02	<0.02	0.23	1.58	4.05	3.15	0.97	0.38	0.02	<0.02	10.4
	084305	N	M	0.5%	<0.03	0.04	0.55	1.89	4.29	3.35	1.66	0.33	<0.03	<0.03	12.1
	084306	N	M	1.6%	<0.02	0.03	1.00	4.32	11.9	12.8	3.38	1.03	0.10	<0.02	34.6
														mean of males =	**22.8**
														mean of females =	**46.0**
Gut Contents														**mean overall =**	**27.6**
PLANTE-F	4188311	Y			0.01N	0.03	0.06	0.11	1.77	0.97J	0.99J	0.14	0.02N	<0.02	4.1 J
NINEMILE-F	4188310	Y			<0.01	0.03	0.04	0.06	2.42	2.02J	1.35	0.21	0.03N	<0.01	6.2 J

[1] These Ninemile fish were collected under the station name "Spokane-F" as part of a concurrent WSTMP study and were analyzed as individuals.
*Mean of replicate analysis.
Detected values are in green highlight.
U: The analyte was not detected at or above the reported result.
J: The analyte was positively identified. The associated numerical value is an estimate.
NJ: There is presumptive evidence that the analyte is present. The associated numerical result is an estimate.

Table 33. 2003-2004 PCB Concentrations in Suckers and Crayfish Tissue from the Spokane River (ng/g, ww).

Station/Tissue	Sample ID	Size	Mean Length (mm)	Lip	1-Cl	2-Cl	3-Cl	4-Cl	5-Cl	6-Cl	7-Cl	8-Cl	9-Cl	10-Cl	Total PCB
Whole Body Suckers*															
STATELINE-F	4324442	Lg	513	4.5%	<0.02	<0.02	0.67	20.7	43.2	39.7	30.8J	5.78J	0.49	0.12	141.5 J
	4324443	Sm	445	3.4%	<0.02	<0.02	0.08	3.77	14.6	20.1J	16.8	3.02	0.40	0.10	59.0 J
														mean=	**100.2**
PLANTE-F	4324440	Lg	479	4.6%	<0.02	0.03	2.26J	30.2	52.4	25.0	25.9J	3.98	0.28	0.05	140.2 J
	4324441	Sm	453	3.3%	<0.02	0.02	0.76	9.71	19.0	12.7J	8.16	2.87J	0.24	0.04	53.5 J
														mean=	**96.9**
NINEMILE-F	4324447/8†	Lg	431	2.6%	<0.02	0.03	0.56J	3.33J	9.22J	11.0J	4.91J	1.27	0.21 J	0.05	30.6 J
	4324450	Sm	355	4.8%	<0.02	0.06	1.01J	3.86	8.77	9.66	3.49	0.79	0.16	<0.04	27.8 J
														mean=	**29.2**
LONGLOW-F	4324444	Lg	463	7.7%	<0.02	0.06	3.41J	43.4	59.7J	53.9J	25.5	8.17J	1.11	0.11	195.4 J
	4324446	Sm	433	9.1%	<0.02	0.06	4.08J	54.7	74.4J	78.0J	32.0	8.59	1.05	0.18	253.1 J
														mean=	**224.2**
Sucker Gut Contents															
PLANTE-F	4324445	--	485	na	<0.02	0.03	1.38	27.6	44.2	26.8J	14.1	3.40	0.28	0.04	117.8 J
NINEMILE-F	4324449	--	396	na	<0.02	0.02	0.03	0.29	1.13	1.48	0.28	0.05	0.02	<0.04	3.3
Crayfish Tail Muscle															
Upriver Dam	4208148	--	40	na	<0.006	0.02	0.01	0.03	0.036	0.05	0.54	0.18J	0.01	<0.01	0.87 J

*Largescale suckers except bridgelip suckers at NINEMILE-F.
†Mean of replicate analysis.
Detected values are in green highlight.
U: The analyte was not detected at or above the reported result.
J: The analyte was positively identified. The associated numerical value is an estimate.

Largescale suckers from Stateline and Plante Ferry had similar PCB concentrations. Composites of large fish had three times the PCB level of the smaller fish composites at both sites even though average lengths were not substantially different (513 vs. 445 mm at Stateline; 480 vs. 453 mm at Plante Ferry). The higher PCB concentrations in the large fish samples from these sites may be due to the 50% higher lipid content, yet even on a lipid-normalized basis, growth dilution does not appear to be a controlling factor in PCB concentrations.

The Lake Spokane largescale suckers had the highest PCB levels. Size disparity was similar (463 vs. 433 mm), and the sample of smaller fish had 30% higher PCB levels, but here again, the difference is not necessarily due to growth dilution since the sample composed of smaller fish had a 20% higher lipid content.

Bridgelip suckers from Ninemile had much lower PCB concentrations than suckers at other locations, possibly due to species difference or the smaller size of fish at Ninemile (large and small composites averaged 431 and 355 mm, respectively). However, PCB contamination of food items also appears to be a major factor since differences in PCB concentrations in whole fish from Plante Ferry and Ninemile reflect differences in PCB levels in gut contents.

Both rainbow trout and suckers appear to show drastic reductions in PCB concentrations compared to previous sampling. PCBs in rainbow trout fillet from Plante Ferry and Ninemile, when compared on a lipid-normalized basis to reduce covariability, have decreased an order of magnitude from 1999. Largescale suckers analyzed in 2003-2004 have approximately one-fifth the PCB concentrations compared to the previous sampling at Plante Ferry (1996) and lower Lake Spokane (2001). Bridgelip suckers collected from Ninemile in 2004 had much lower total PCB concentrations than the previous [largescale] sucker sampling at this location (880 ng/g lipid in 2004 vs. 31,000 ng/g lipid in 1999).

PCB concentrations in largescale suckers from Plante Ferry and lower Lake Spokane appear to be similar to “boundary conditions” at Stateline when compared on a lipid-normalized basis. This may suggest, generally, that PCB concentrations in certain Washington reaches of the Spokane River are in essence equilibrating to general conditions upstream in Idaho. A recent study of PCBs in Lake Coeur D’Alene fish (SAIC, 2003b) found a total PCB concentration of 1,580 ng/g lipid in whole largescale sucker, similar to the levels in Stateline suckers (2,440 ng/g lipid) as well as other locations analyzed during the present survey (2,340 ng/g lipid at Plante Ferry and 2,660 ng/g lipid at lower Lake Spokane).

An industrial or commercial legacy of PCB contamination is evident in the northern portion of Lake Coeur D’Alene. The SAIC study collected suckers (combined long-nose and large-scale) specifically around the area known as Blackwell Island, just outside the City of Coeur D’Alene. This location is the start of the Spokane River and has a long industrial history. The whole body sucker composites (combined long-nose and large-scale) ranged from 158 to 443 ug/Kg total PCBs. Large-scale sucker fillets collected more broadly from the north quadrant of the lake ranged from 52 to 124 ug/Kg. Much lower levels of 9 to 15 ug/Kg were found in kokanee and largemouth bass fillets more widely composited from the north quadrant of the lake.

Crayfish from the Upriver Dam fine-grained sediment site showed low levels of PCBs in tail muscle (0.87 ng/g total PCB). Previous analyses of muscle tissue from Spokane River crayfish also found mostly undetectable or low (≤ 7 ng/g total PCB) concentrations, indicating crayfish muscle is a poor sentinel of PCB contamination. Whole crayfish have not been analyzed and could have higher PCB concentrations due to gut contents or accumulation in hepatopancreas or other organs.

2005

Table 34 summarizes the data obtained on PCB levels in Spokane River fish during 2005, (Serdar and Johnson, 2006). Mean concentrations of total PCBs (sum of detected Aroclor-equivalents) ranged from 37-234 ug/Kg in sport fish fillets and 56-1,823 ug/Kg in whole largescale suckers.

Table 34. Summary of PCB Concentrations Measured in Spokane River Fish Collected in 2005.

Reach	Species	N* =	Total PCBs (ng/g, wet weight)	
			Mean	Range
Fillet Samples				
Plante Ferry	Rainbow Trout	3	55	48 - 68
Mission Park	Rainbow Trout	3	153	118 - 220
	Mountain Whitefish	3	234	203 - 280
Ninemile	Rainbow Trout	3	73	46 - 94
	Mountain Whitefish	3	139	86 - 172
Upper Lake Spokane	Mountain Whitefish	3	43	36 - 55
	Brown Trout	1	130	- -
	Smallmouth Bass	1	37	- -
Lower Lake Spokane	Mountain Whitefish	6	76	<9.6 - 190
	Smallmouth Bass	3	67	49 - 82
Whole Body Samples				
Stateline	Largescale Sucker	3	56	16 - 77
Plante Ferry	Largescale Sucker	3	122	91 - 180
Mission Park	Largescale Sucker	3	1,823	1,100 - 3,000
Ninemile	Bridgelip Sucker	3	69	52 - 94
Upper Lake Spokane	Largescale Sucker	3	327	160 - 510
Lower Lake Spokane	Largescale Sucker	3	254	109 - 396

*Composites of 4-5 individual fish each, except lower Lake Spokane mountain whitefish were analyzed individually.

In both types of samples, concentrations gradually increased between the Stateline and Mission Park reaches, then decreased from Mission Park down into lower Lake Spokane. The concentrations in Lake Spokane were higher than in the upper part of the river at Stateline and Plante Ferry.

Fish tissue studies often differ in sample size, use of composites vs. individual fish samples, and in other ways and are not appropriate for statistical testing for long-term trends. Therefore a qualitative, weight-of-evidence approach was taken for identifying long-term changes in PCB levels, coupled with a statistical test for significant differences for the limited instances where comparable data exist.

The data were examined to determine if it would be appropriate to normalize to the lipid content of the samples, since concentrations of PCBs and other organochlorines sometimes vary directly with lipid content. For the majority of species and locations, there was not a good correlation between total PCBs and percent lipids (Serdar and Johnson, 2006).

Serdar and Johnson (2006) identified seven data sets, by river reach, where the same fish species and tissues were analyzed for two or more time periods and where the sample size and type was sufficient for statistical analysis (Table 35). They found substantial decreases in fish tissue PCB concentrations for the following reaches:

- Plante Ferry
- Mission Park
- Ninemile
- Upper Lake Spokane

Table 35. Significant Changes Identified in Total PCB Concentrations in Spokane River Sportfish Fillets: Results from Analysis of Variance on Comparable Data Sets, 1994-2005.

Reach	Species	Sample Type	Time Period	*p* value (Probability)	Significant Change? ($p < 0.10$)
Plante Ferry	Rainbow Trout	composites	1994-1996	1.00	No
			1996-2005	0.34	
			1994-2005	0.01	Decrease
Mission Park	Rainbow Trout	composites	1994-2005	0.85	No
	Mountain Whitefish			0.02	Decrease
Ninemile	Rainbow	composites	1994-1996	0.07	Decrease
			1996-2005	1.00	No
			1994-2005	0.06	Decrease
		individuals	1996-2005	0.00	
	Mountain Whitefish	composites	1994-1996	0.01	Increase
			1996-2005	0.01	Decrease
Upper Lake Spokane	Mountain Whitefish	composites	2001-2005	0.05	Decrease

Appendices D and E of Serdar and Johnson (2006) have the total PCB data for all Spokane River fish tissue samples analyzed by Ecology from 1993 to 2005.

Results of this analysis suggest that, at least for these two species, there has been a significant decrease in PCB concentrations between 1994 and 2005. Evidence for a similar decrease in the Mission Park reach was equivocal. The general picture that emerges from the historical data on the Spokane River is one of decreasing PCB concentrations in fish from all areas of the river since 1994, except perhaps Mission Park.

The long-term declines in PCBs noted along the upper Spokane River both statistically and qualitatively are consistent with recent Ecology regulatory and investigatory actions that are yielding reductions in PCBs entering the river from NPDES discharges and remedial actions associated with cleanups at a major industrial facility. Lake Spokane may also be responding to the actions taken in the upper river. The apparent lack of a decline in PCB levels in fish from the Mission Park reach is consistent with stormwater discharge being the largest current source of PCBs to the river.

Table 36 compares the 2005 results with statewide data on PCBs in freshwater fish, based on fillet data reported by Seiders and Kinney (2004) and whole fish data reported by Davis et al. (1994, 1995, 1996, 1998). The fillet samples were primarily collected during 1995-2002; the whole fish samples are from 1992-1995. To avoid biasing the statewide results high, data for Spokane River fish were excluded. The statewide data do not represent “background” sampling from waters generally free of human influences, but are from various waters around the state including lakes, rivers, and streams also impacted by industrial and municipal discharges.

Table 36. Total PCB Concentrations in Spokane River Fish vs. Statewide Data (ug/Kg, wet weight).

Total PCBs	Spokane River 2005		Statewide	
	Fillet N=24	Whole Body N=24	Fillet N=98	Whole Body N=28
Mean	104	442	155	151
Median	78	135	28	87
Minimum	36	16	1.2	7.1
Maximum	280	3,000	1,943	622
90th percentile	213	1,181	297	334

For the most part, PCB concentrations in the 2005 Spokane River fillet samples are in the range of the statewide mean and median for fillets. The whole fish results for Mission Park and Lake Spokane are at or above the upper end of the range of whole fish statewide values.

Ecology recently completed an assessment of PCB levels in fish from background lakes, rivers, and streams throughout Washington (Johnson et al., 2010). Table 37 compares the results with the 2005 Spokane River edible fish tissue data. Whole body samples were not analyzed for the background study.

Statewide data obtained through the background study suggest that Spokane River fish are elevated by about an order of magnitude over other waterbodies with no obvious sources of contamination. It should be recognized, however, that the local background in the Spokane region may differ from these statewide results.

Table 37. Total PCB Concentrations in Spokane River Fish vs. Statewide Freshwater Background (ug/Kg, wet weight; fillet samples).

Total PCBs	Spokane River 2005 N=24	Statewide Background N=52
Mean	104	4.9
Median	78	1.4
Minimum	36	0.04
Maximum	280	88
90^{th} percentile	213	6.5

Assessment of PCB Sources

The following section contains an assessment of PCB sources to the Spokane River, which include industrial and municipal effluents, stormwater, the Spokane River at the state line with Idaho, and the Little Spokane River. Loads from other sources are considered inconsequential (Ecology, 1995; Golding, 1996, 2001, 2002).

Deep Creek was initially considered for source assessment in the present study, but the lower section of the creek appears to be a hydraulically losing reach, and no water was present. Previous monitoring of Latah Creek detected no PCBs in the sediments (Johnson and Norton, 2001). The potential for other small tributaries to deliver PCBs to the Spokane River was considered low, and they were not sampled.

Other possible secondary sources to consider are groundwater and atmospheric deposition.

Groundwater has previously been monitored at the Kaiser Trentwood facility to assess its potential as a source of PCBs to the Spokane River, but Hart Crowser (1995) concluded that groundwater inflow was not a primary PCB transport pathway to the river from the facility. In addition, Ecology's Toxics Cleanup Program currently is overseeing the cleanup of PCBs at Kaiser Trentwood to ensure groundwater contamination will not impact the river.

Atmospheric deposition of PCBs is known to be pronounced in areas where cold condensation occurs, such as in the mountains of southern British Columbia and Alberta (Blais et al., 1998). This phenomenon holds the potential to deposit measurable quantities of PCBs in the mountains in the eastern portion of the Spokane River basin, eventually delivering PCBs to Lake Coeur D'Alene through the St. Joe, St. Maries, and Coeur D'Alene Rivers and, excluding industrial sources in Idaho, may partially explain higher than expected concentrations of PCBs in fish from Lake Coeur D'Alene. Delivery of PCBs to Washington from this source would be integrated to a single channel: the Spokane River at Stateline.

The Spokane River basin downstream of the Idaho border would not be ideal for atmospheric deposition due to aridity of the region, and PCBs that are deposited in the area would theoretically be integrated into delivery systems already considered, such as the Little Spokane River and urban stormwater. Deposition of PCBs directly to the surface of the Spokane River would be minimal due to its small surface area relative to the basin area. Atmospheric deposition is an un-quantified source of PCBs to the Spokane River.

Loss of PCBs to the atmosphere through volatilization has also not been quantified. PCB budgets for the Great Lakes area have shown atmospheric flux to be an order of magnitude greater than input and output through surface waters, with loss through volatilization approximately five times greater than atmospheric deposition (EPA, 1993).

PCB Loading Calculations

PCB loads calculated for the present 2003-07 study only include surface water inputs and outflow, generally using the following formula:

Equation 6. Daily Load (mg/day) = C_w x (10^{-9} mg/pg) x Q x (86,400 s/day)

Where:

- C_w (concentration in whole water) = concentration of PCBs in water (pg/l).
- Q (discharge) = flow of the delivery system being considered (L/sec).

To simplify the data presentation and maintain consistency with applicable criteria, loads are calculated for total PCBs only.

Industrial and Municipal Effluents

Table 38 shows PCB loads in effluents identified as PCB sources in this study. PCB loads from Liberty Lake WWTP, Inland Empire, and the Spokane WWTP were calculated using a combination of results from the present survey and previous sampling (Table 21). For the Liberty Lake and Spokane WWTPs, loads were calculated using the mean total PCB concentrations and instantaneous flows from 2001 and 2003-2004. For Inland Empire, loads were calculated using the mean total PCB concentrations and instantaneous flows from 2001, 2002, and 2003-2004. In samples where no PCBs were detected, reporting limits were used to calculate the average.

PCB loads from Kaiser were based on total PCB concentrations and instantaneous flows from nine samples collected during 2004 and 2005 (Table 20) since these represent the most current data on PCBs in Kaiser effluent.

Table 38. Estimated PCB Loads in Industrial and Municipal Effluents Discharged to the Spokane River.

Facility	RM	Total PCB (pg/l)	Discharge (ML/day)	Total PCB Load (mg/day)
Liberty Lake WWTP	92.7	1,121	2.5	2.9
Kaiser Trentwood	86.0	1,080	60	65
Inland Empire Paper	82.5	2,544	18	45
Spokane WWTP	67.4	1,364	143	194
			Total =	307

ML/day = megaliters/day [0.264 MGD (million gallons per day)].

Urban Stormwater Runoff

For the sampling conducted in 2004, PCB loads delivered to the Spokane River through stormwater were calculated using the "Simple Method" model to estimate runoff volume and calculate contaminant loads (www.stormwatercenter.net/).

For 2007, Parsons calculated the loads from sampled and un-sampled drains in the City of Spokane using two different discharge estimates: (1) calculated by the Simple Method to be consistent with the 2004 data, and (2) the reported discharge volumes from the City of Spokane's CSO Annual Report for fiscal year 2005. Both loading scenario calculations for the un-sampled drains used the average concentration from the sampled drains. Parsons concluded that the actual loading of PCBs to the river from stormwater is likely somewhere between the two estimates.

For the source assessment study, the loads from the stormwater sewer network were calculated as the sum of the load determined by the Simple Method for the sampled storm drains and the load using the 2005 discharge volumes for the un-sampled storm drains. The magnitude of stormwater discharge plays a large role in the loading calculations. Parsons stated that because direct untreated CSO discharges may occur only during large runoff events, the Simple Method was considered an upper bound.

The sum load from the sampled stormwater basins using the Simple Method was 557 mg/day total PCBs, and the un-sampled stormwater basins using the discharge records from the City of Spokane was 133 mg/day total PCBs.

The Simple Method uses the formula:

Equation 7 $L = 0.226 * R * C * A$

Where:

- L = Annual load (lbs).
- R = Annual runoff (inches).
- C = Pollutant concentration (mg/L).
- A = Area (acres).
- 0.226 = Unit conversion factor.

Annual runoff and runoff coefficient were previously presented as Equations 4 and 5.

Tables 39 and 40 show the estimated PCB stormwater loads in the sampled and un-sampled stormwater basins (data from Parsons, 2007).

The total stormwater load (691 mg/day) from the City of Spokane is considered to be the sum of the high load scenario for the sampled stormwater outfalls above and below Monroe St. Dam (557 mg/day) Table 39, and the low load scenario (133 mg/day) for the un-sampled stormwater outfalls, Table 40. The locations of the un-sampled stormwater outfalls were assumed to be half above and half below the Monroe St Dam.

Table 39. PCB Load from Sampled Stormwater Basins based on Simple Method Discharges, Parsons (2007).

Location_ID[1]	Average t-PCB (ng/L)[2]	Annual t-PCB Load (lb)[3]	Daily t-PCB Load (mg/day)[4]	Annual t-PCB Load/Acre (mg/acre)
Sampled Stormwater Basins (High CSO Load Scenario)				
Above Monroe St Dam				
GREENE	19.5	0.001	1	12.2
MISSION	16.5	0.001	1.2	8.2
RIVERTON	22.3	0.005	6	9.1
SUPERIOR	17.8	0.007	9	11.5
UNION	97	0.013	16	54.8
ERIECSO (CSO 34)	177	0.336	417	78
WASHINGT	4.05	0.003	3.6	2.9
HOWARDBR	8.74	0.001	0.9	6
Below Monroe St Dam				
LINCOLN	4.36	0.001	0.7	3.9
CLARKE (CSO 24A)	2.56	0.005	6	1.2
7TH (CSO 26)	3.38	0.003	4	2.5
COCHRAN	12.9	0.072	90	6.3
HSTREET (CSO 7)	2.49	<0.001	0.4	1.1
HWY291	0.978	0.002	2	0.4
Totals		0.45	**557**	198

[1] In EIM these Locations IDs have the prefix STMWTR_; and CSO # in parentheses is not part of Location ID.
[2] Average of all the samples collected in the 2007 Parsons study; the PCB average was updated by Ecology.
[3] Calculated using Equation (5).
[4] Daily PCB load (mg/day) = Annual load (lb/yr)*453000 mg/lb /365.
Rows highlighted in green correspond to CSO basins.

Table 40. PCB Load from Un-Sampled Stormwater Basins based on 2005 City Discharge Data, Parsons (2007).

Location_ID[1]	Average t- PCB (ng/L)[2]	Annual t-PCB Load (lb)[§]	Daily t-PCB Load (mg/day)[#]	Annual t-PCB Load/Acre (mg/acre)
29 Un-Sampled Stormwater Basins (Low CSO Load Scenario)				
I05 Upper	23	0.014	17.82	8.7
I04	23	0.007	8.57	18.0
I07	23	0.004	5.01	10.1
CSO 33B	23	0.022	27.80	9.2
CSO 06	23	0.012	14.90	11.3
CSO 12	23	0.010	13.02	12.4
I03	23	0.001	0.73	1.9
CSO 23	23	0.005	5.96	13.3
CSO 41	23	0.002	2.37	9.7
CSO 16B	23	0.002	2.41	7.4
CSO 25	23	0.001	1.08	18.7
CSO 33D	23	0.002	2.41	17.9
CSO 14	23	0.002	1.95	10.0
CSO 10	23	0.001	1.79	11.9
CSO 15	23	0.003	3.64	10.8
CSO 42	23	0.000	0.37	22.5
CSO 40	23	0.002	1.92	12.3
CSO 39	23	0.001	1.60	11.4
CSO 33A	23	0.001	1.77	9.7
CSO 38	23	0.002	2.19	11.2
CSO 24B	23	0.003	3.54	18.2
CSO 33C	23	0.001	0.85	19.3
CSO 20	23	0.005	6.65	9.6
CSO 02	23	0.002	1.95	11.1
CSO 19	23	0.001	0.99	10.6
CSO 16A	23	0.001	0.76	10.7
CSO 03C	23	0.000	0.34	12.3
CSO 18	23	0.000	0.22	6.1
CSO 34TOSVI	23	0.000	0.15	10.9
Totals		0.11	133	347

[1] In EIM these Locations IDs have the prefix STMWTR_; and CSO # in parentheses is not part of Location ID.
[2] Average of all the samples collected in the 2007 Parsons study; the PCB average was updated by Ecology.
[3] Calculated using Equation (5).
[4] Daily PCB load (mg/day) = Annual load (lb/yr)*453000 mg/lb /365.
Rows highlighted in green correspond to CSO basins.

Parsons found the largest stormwater PCB loads to the Spokane River originate from the Cochran, CSO 34, Union Street, and I05 Upper stormwater basins under both discharge scenarios.

Instream Loads

Harmonic Mean Flow

The harmonic mean flow is recommended by EPA (1991a) for use in assessing a river's loading capacity for long-term exposure to carcinogens such as PCBs. Harmonic mean is the appropriate measure of central tendency when dealing with rates, in this case rates of flow. The harmonic mean is less than the arithmetic mean and is expressed as $Q_h = n/\sum(1/Q_i)$, where n is the number of recorded flows and $\sum(1/Q_i)$ is the sum of the reciprocals of the flows.

As noted by EPA (1991b), the harmonic mean "provides a more reasonable estimate than the arithmetic mean to represent long-term average river flow. Flood periods in rivers bias the arithmetic mean above the flows typically measured. This overstates available dilution. The calculation of the harmonic mean, however, dampens the effect of peak flows. As a result, bias is reduced. The harmonic mean is also an appropriate conservative estimate of long-term average flow in highly regulated river basins, such as the Columbia. In a regulated river basin, the harmonic mean and the arithmetic average are often much closer numerically."

PCB Loads in the Spokane River at the Idaho Border

PCB loads at the Idaho border were calculated using the average dissolved total PCB concentration from 2003-2004 Stateline SPMD data and historic harmonic mean flow at USGS Gage 12419500 (Spokane River above Liberty Bridge). Two methods were used to calculate the whole water PCB concentrations: (1) extrapolation using the dissolved fraction estimated from Equation 3 and (2) addition of the solid component measured in Harvard Rd. suspended particulate matter (Table 41). Both methods yield an estimated total PCB load of approximately 480 mg/day. Results using the two methods are nearly identical since the theoretical dissolved fraction (0.92) is similar to the measured dissolved fraction (0.91).

Table 41. PCB Loads in Spokane River at Idaho Border.

Station	RM	Harmonic Mean Flow (L/sec)	Method for Calculating C_w	Component	Mean Total PCB C_w (pg/l)	Total PCB Load (mg/day)
Stateline	96.1	52,151*	Stateline SPMD (C_d) /diss fraction (0.92) from Equation 3	**C_w=**	**106**	**477**
Harvard	92.8	52,151*	Stateline SPMD (C_d) + Harvard suspended particulate matter (C_s)	Diss. (C_d)	97	439
				Solid (C_s)	10	43
				Total (C_w)=	**107**	**482**

* Flow from USGS Station 12419500: Spokane River above Liberty Br (RM 93.9).
C_w Concentration in whole water.

PCB Loads in the Little Spokane River

PCB loads in the Little Spokane River were calculated using the average Little Spokane SPMD data from 2003-2004 and historic flows at USGS Gage 12431000 (Little Spokane River at Dartford). Equation 3 was used to estimate dissolved and solid-phase fractions based on TSS concentrations in the Little Spokane River.

The estimated average total PCB load in the Little Spokane River is 97 mg/day (Table 42). Approximately 74% of this load is in the dissolved phase, based on estimation using Equation 3 and an average TSS of 5 mg/L.

Table 42. PCB Loads in the Little Spokane River.

Location	RM	Harmonic Mean Flow (L/sec)	Mean Total PCB C_d (pg/l)	Fraction C_d	Mean Total PCB C_w (pg/l)	Total PCB Load (mg/day)
Little Spokane R.	56.3	5,619*	147	0.74	199	96.6

* Flow from USGS Station: 12431000 Little Spokane River @ Dartford.

PCB Loads in the Mainstem Spokane River

PCB loads estimated from the 2003-2004 monitoring are shown in Table 43. Loads were calculated as described previously, i.e., using harmonic mean flows (from Figure 3), mean data collected using SPMDs, and application of Equation 3 to estimate total PCB concentrations from the dissolved fraction.

Table 43. Instream PCB Loads in Spokane River Reaches and the Little Spokane River.

Location	RM	Harmonic Mean Flow (L/sec)	Mean Total PCB C_d (pg/l)	Fraction C_d	Mean Total PCB C_w (pg/l)	Total PCB Load (mg/day)
Stateline	96.1	52,151[a]	97	0.92	106	477
Upriver Dam	80.3	53,081[b]	68	0.88	77	354
Upriver Dam (bottom)	80.3	53,081[b]	138	0.88	157	721
Monroe St.	74.8	82,239[c]	179	0.90	199	1,413
Ninemile	63.6	82,758[d]	265	0.85	311	2,281
Lower Lake Spokane	38.4	106,329[e]	332	0.83	399	3,664
Little Spokane R.	56.3	5,619[f]	147	0.74	199	97

[a] Flow from USGS Station 12419500: Spokane River above Liberty Br. (RM 93.9).
[b] Flow from USGS Station 12419500: Spokane River above Liberty Br. (RM 93.9) plus sum of flows from municipal and industrial facilities.
[c] Flow from USGS Station 12422500: Spokane River at Spokane (RM 72.9).
[d] Sum of Flows from USGS Station 12422500: Spokane River at Spokane (RM 72.9) and Station 12424000 – Latah (Hangman) Creek at Spokane (RM 72.2).
[e] Flow from USGS Station 12433000: Spokane River at Lake Spokane (RM 33.8).
[f] Flow from USGS Station 12431000: Little Spokane River at Dartford (RM 56.3).

In the mainstem Spokane River, PCB loads spanned an order of magnitude, from 350 mg/day at Upriver Dam to 3,700 mg/day at lower Lake Spokane (Figure 19). Higher PCB concentrations occurred in reaches with higher flows, compounding the increase in estimated loads traveling downstream. One exception to this pattern occurs at Upriver Dam (mid-depth), where all of the PCB loading can be attributed to loads moving downstream from the Idaho border (Stateline). Although PCB loads estimated at the bottom of the water column are twice those in the middle column, the mid-column loads are probably more representative of the actual river conditions whereas the bottom loads are influenced by localized conditions as discussed previously. With successful completion of the Upriver Dam cleanup, lower bottom-water concentrations of PCBs would be expected.

Loads were not calculated for Little Falls reservoir or the Spokane Arm due to the absence of PCB data from these reaches. However, it is reasonable to assume that instream loads at Little Falls are identical to those at Lake Spokane since there are no known additional PCB sources to the Little Falls reservoir, flow contributions or losses to the reservoir are minor, and residence time is short since Little Falls is a run-of-the-river dam.

These conditions are also true for the upstream half of the Spokane Arm which is free-flowing. The assumption of identical loads in the lower half of the Spokane Arm (approximate delineation at Porcupine Bay [RM 13]) is tenuous due to the influence of Lake Roosevelt which backs up the water in this reach during most of the year and has an undetermined effect on PCB concentrations and loads. Limited evidence suggests that Lake Roosevelt itself contributes at most a small portion of the PCBs to the Spokane Arm and more likely has a diluting effect. PCB concentrations in Lake Roosevelt fish tissues have been low compared to fish from the lower reaches of the Spokane River (EVS, 1998; Munn, 2000).

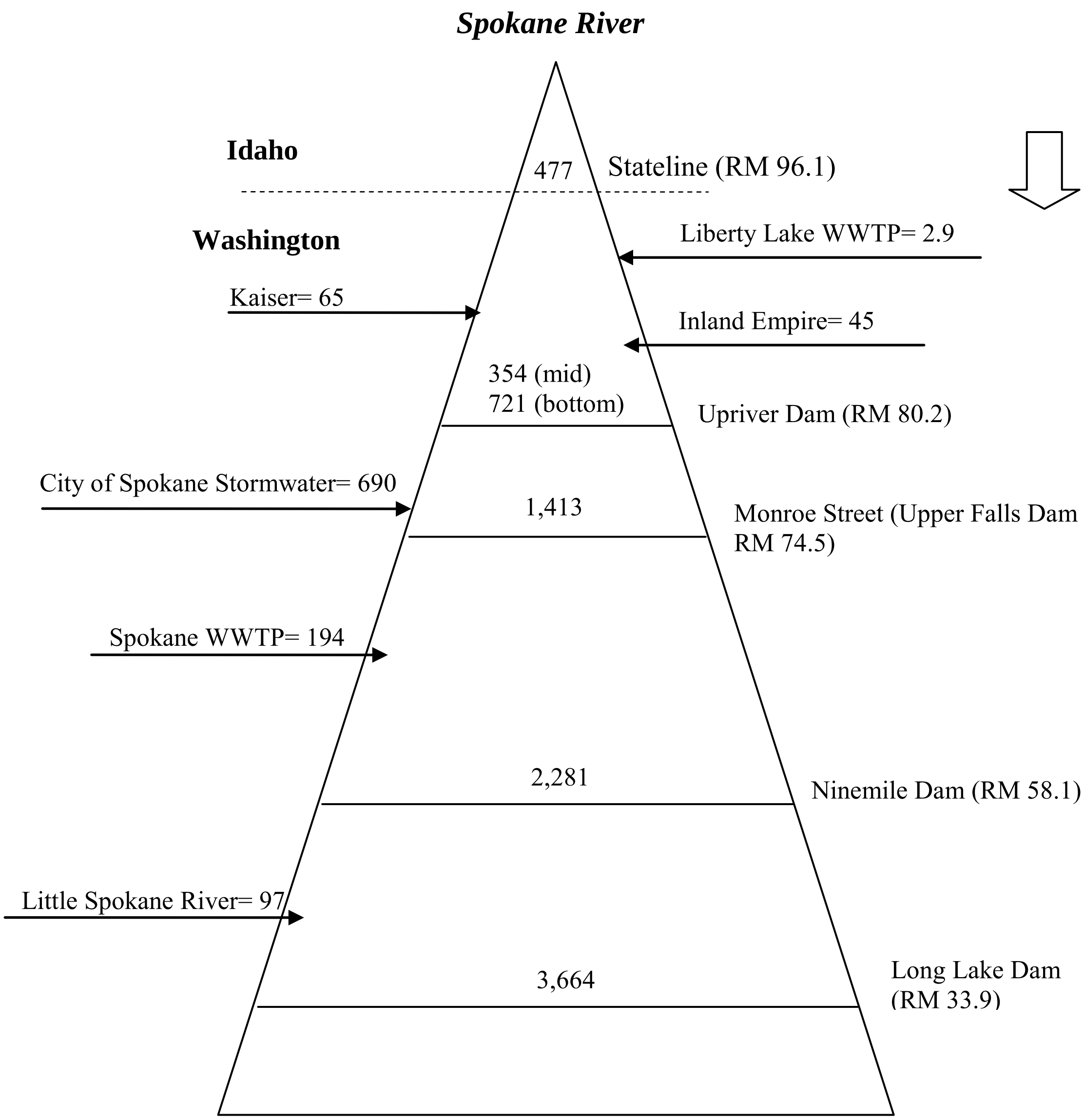


Figure 19. Schematic of PCB Sources and Instream Loads in the Spokane River (total PCB, mg/day).

Load Reductions Needed to Meet Human Health Criteria

Table 44 shows estimates of the reduction in PCB loads that would be needed to meet NTR and Spokane Tribe human health water quality criteria in the mainstem Spokane River and Little Spokane River. The "current" PCB loads were calculated in the preceding section of this report.

Table 44. Estimates of PCB Load Reductions Needed to Meet Human Health Water Quality Criteria in the Spokane River (based on 2003-04 water column data).

<table>
<tr><th rowspan="2">Location on Spokane River</th><th rowspan="2">Harmonic Mean Flow[a] (l/d)</th><th rowspan="2">Current t-PCB Conc.[a] (pg/l)</th><th rowspan="2">Current t-PCB Load (mg/day)</th><th colspan="2">Target t-PCB Load (mg/day) at Water Quality Criterion</th><th colspan="2">t-PCB Load Reduction Required to Meet Water Quality Criterion</th></tr>
<tr><th>NTR (170 pg/l)</th><th>Spokane Tribe (3.37 pg/l)</th><th>NTR</th><th>Spokane Tribe</th></tr>
<tr><td>Stateline</td><td>4.51E+09</td><td>106</td><td>477</td><td>766</td><td>15</td><td rowspan="2">none required</td><td>97%</td></tr>
<tr><td>Upriver Dam</td><td>4.59E+09</td><td>117</td><td>537</td><td>780</td><td>15</td><td>97%</td></tr>
<tr><td>Monroe St.</td><td>7.11E+09</td><td>199</td><td>1,413</td><td>1,208</td><td>24</td><td>15%</td><td>98%</td></tr>
<tr><td>Ninemile</td><td>7.31E+09</td><td>311</td><td>2,281</td><td>1,243</td><td>25</td><td>46%</td><td>99%</td></tr>
<tr><td>Little Spokane River</td><td>4.85E+08</td><td>199</td><td>97</td><td>83</td><td>2</td><td>15%</td><td>98%</td></tr>
<tr><td>Lake Spokane (lower)</td><td>9.19E+09</td><td>399</td><td>3,664</td><td>1,562</td><td>31</td><td>57%</td><td>99%</td></tr>
<tr><td>Little Falls</td><td>9.19E+09</td><td>399</td><td>3,664</td><td>1,562</td><td>31</td><td>57%</td><td>99%</td></tr>
<tr><td>Spokane Arm</td><td>9.19E+09</td><td>399</td><td>3,664</td><td>1,562</td><td>31</td><td>57%</td><td>99%</td></tr>
</table>

[a] From Table 43

During 2003-04, the Spokane River was meeting the NTR criterion for water (170 pg/l) between Stateline and Upriver Dam but not further downstream. Load reductions of 15-57% would be required to meet this criterion throughout the river, with the largest reductions needed in and below the Ninemile reach. A 15% reduction is called for in the Little Spokane River.

Very large reductions in loading would be required to meet the much more restrictive Spokane Tribe criterion (3.37 pg/l). These range from 97% at Stateline to 99% by Ninemile.

In order for the Spokane River to achieve compliance with human health water quality criteria, reduction of similar magnitude may be needed in loading from municipal and industrial discharges that have been identified as PCB sources. In the Washington reaches of the river, stormwater carries the largest PCB load and is thus the most important source to reduce.

Food Web Bioaccumulation Model

Fish accumulate PCBs through a variety of pathways including bio-concentration (direct uptake of dissolved PCBs in water through the gills and skin), diet, and, in some cases, direct ingestion of sediment. Both the NTR and Spokane Tribe water quality criteria may underestimate the PCB concentrations that will result in a fish because bio-concentration is the only accumulation mechanism considered in the NTR. Previous studies in the Spokane River have found the bio-concentration factor (BCF) of 31,200 L/kg used to derive this criterion to be a poor link between PCB concentrations in water and fish tissue. For instance, Jack et al. (2003) estimated that the BCF explained no more than 23% of the PCB accumulated in Spokane River fish tissue. To accurately relate water concentrations to fish tissue, all pathways must be considered including direct and indirect contributions from sediments.

It is widely recognized that bioaccumulation factors (BAFs) describe a much more meaningful relationship between water and tissue concentrations than BCFs (EPA, 2000b). Like BCFs, BAFs numerically describe the link between water concentrations and accumulation in tissue, but they integrate all exposure pathways (bio-concentration, diet, other sources) and therefore more accurately reflect the water-tissue relationship. Using a simplified computation method, BAFs for the Spokane River were estimated to be in the range of 10^5 - 10^6 L/kg (Jack et al., 2003).

In some cases, sediment may be a more important pathway for PCB exposure in fish, either through consumption of benthic organisms as prey or through direct ingestion of sediments. In instances where sediment exposure is important, the relationship is described as the biota-sediment accumulation factor (BSAF), a tissue concentration divided by a sediment concentration and usually normalized to lipid in tissue and organic carbon in sediment. If a BSAF is much better than a BAF at describing the link between contaminants in the aquatic environment and fish tissue concentrations, then sediment recovery rates (either natural or through cleanup actions) applied to BSAFs may be used to predict contaminant declines in fish tissues. In Lake Spokane, the sediment BSAF calculated from mean sediment and fish tissue concentrations was 10.9 (Jack et al., 2003).

Neither the BAF nor the BSAF by themselves can accurately describe the link between PCBs in the aquatic environment and fish tissue. Because of the interactions among water, sediments, and biota (prey items), it is impossible to account for fish tissue concentrations resulting from exposure to these sources when they are considered independently. Therefore, a mathematical food web bioaccumulation model was used to estimate PCB concentrations in fish tissue and prey items from concentrations in water and sediment.

Water or sediment quality targets based on the model have no regulatory standing without first meeting procedural requirements of site-specific criteria development. However, model development may be a useful exercise to determine if the existing numerical approach is adequate and if site-specific criteria are warranted.

The Model

A food web bioaccumulation model developed by Arnot and Gobas (2004) was selected to predict the PCB concentrations in fish tissues. This model calculates site-specific concentrations of hydrophobic organic chemicals in multiple aquatic ecosystem compartments and is a refinement of a widely used model previously developed by Gobas (1993). The model cannot only be used to predict PCB concentrations in fish tissue, BAFs, and BSAFs using relatively few input parameters, but more importantly, the model can be used to back-calculate PCB concentrations in water and sediment from target PCB concentrations in fish tissue.

A model such as this has potential value for affirming targets for both tribal and non-tribal fish consumers in specific localized areas of the river. In this way, local targets can be set to guide immediate efforts at improving conditions nearer sources, within the realm of practicability.

Details of the Arnot/Gobas model are in Appendix H.

Target Water and Sediment Concentrations

The Spokane Tribe fish tissue criterion for PCBs (0.1 ng/g) was used to calculate target PCB concentrations in water and sediment. The study area was divided into five reaches to establish target PCB loads: Stateline-Upriver Dam, Monroe Street-Ninemile, Lake Spokane, Little Falls, and Spokane Arm. The four reaches upstream of Lake Spokane were collapsed into two – Stateline-Upriver Dam and Monroe Street-Ninemile – due to the lack of input parameters for individual reaches. The Monroe Street-Ninemile reach includes the section from Upriver Dam to Monroe Street dam. Some of the input parameters for Little Falls and Spokane Arm were out-of-date; Lake Spokane input parameters were used for these reaches with the exception of sediment TOC data which were collected at all locations for the present study. Table H-1 shows input parameters used in the model.

Dissolved water and sediment total PCB concentrations predicted to yield the Spokane Tribe criterion of 0.1 ng/g for total PCB in rainbow trout and sucker fillet are shown in Figures 20 and 21. Results show that PCB concentrations in water and sediment one to four orders of magnitude lower than present would be required to achieve the Spokane Tribe fish tissue criterion. The model illustrates the influence of PCBs in sediments on fish tissue, either through the food web or through direct ingestion, and offers a striking contrast to the simple BCF model which ignores PCBs in sediments and diet. When sediment PCB concentrations are set to zero, effectively reducing the food web model to the BCF model, rainbow trout fillet is predicted to have 0.1 ng/g total PCB at whole-water concentrations similar to the BCF model (3.37 pg/l).

Selection of water concentration targets for PCBs is subjective because it depends on sediment PCB concentrations, and conversely, target levels of PCBs in sediments depend on water PCB concentrations. In essence, both water and sediment critical values for PCBs are “moving targets” at an established tissue concentration. This is further complicated by differences in the two fish species being considered at each reach. As a practical matter, the recommended approach to establish target values is to select water and sediment concentrations where lines for rainbow trout and suckers intersect on each of the water-sediment plots in Figures 20 and 21.

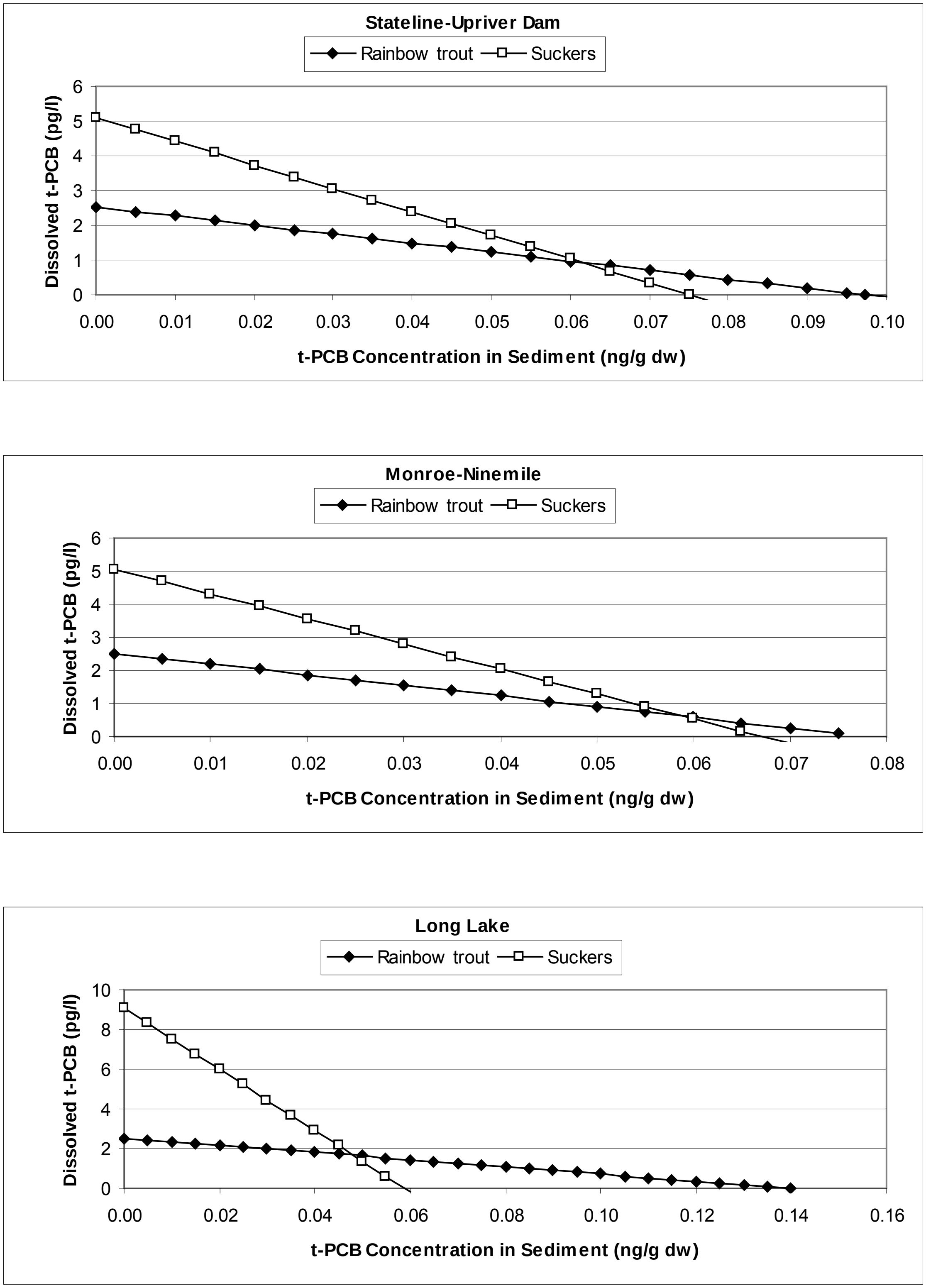
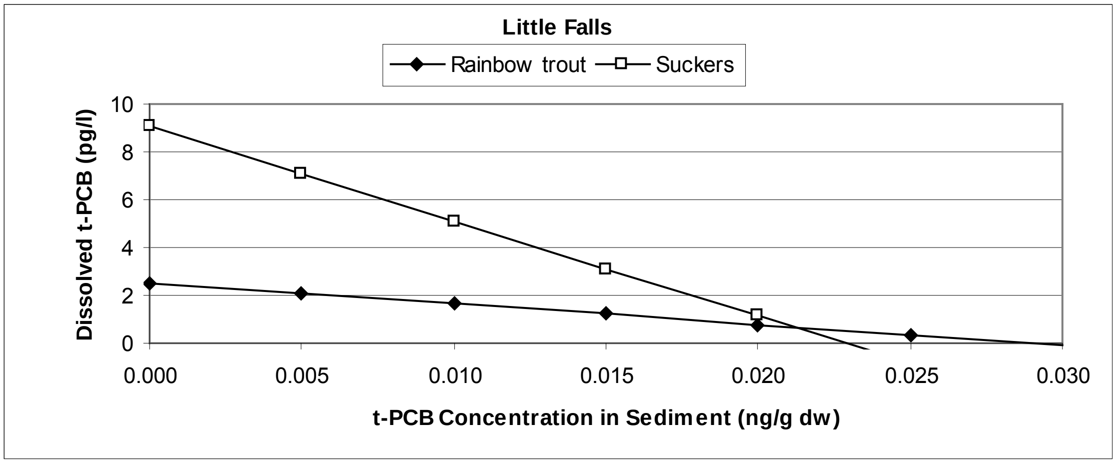


Figure 20. Dissolved Water and Sediment Total PCB Concentrations Predicted to Yield 0.1 ng/g in Rainbow Trout and Sucker Fillet (Stateline to Lake Spokane).



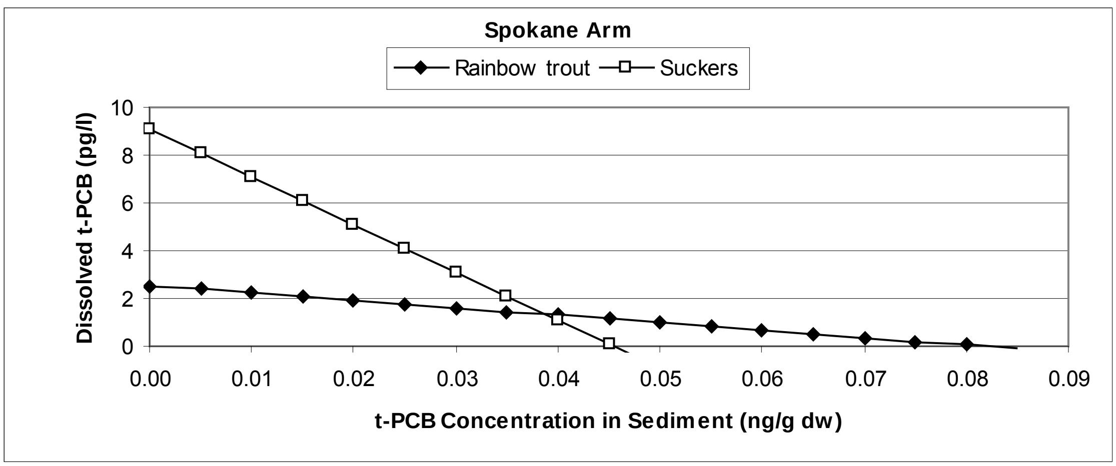


Figure 21. Dissolved Water and Sediment Total PCB Concentrations Predicted to Yield 0.1 ng/g in Rainbow Trout and Sucker Fillet (Little Falls and Spokane Arm).

By using the intersection of two disparate species, the resulting targets will likely be protective of other species that might be consumed. The target water and sediment values may then be computed by setting the equations for each line equal to one another ($[m \times C_s + b]_{Rainbow} = [m \times C_s + b]_{Sucker}$) and solving first for sediment concentration (C_s) and then for water concentrations ($C_d = m \times C_s + b$). This approach effectively halves the number of target values required.

Table 45 shows water and sediment targets for PCBs in the Spokane River, calculated using the food web bioaccumulation model. The targets for water are two to five times lower than those established using the Spokane Tribe water criterion.

Here again, the reductions needed in PCB concentrations and loads to meet the model-based targets would be very large. All discharges would require PCB load reductions of ≥99%. In addition, concurrent reductions of ≥99% are indicated for sediment PCB concentrations.

Table 45. Target Sediment and Water Total PCB Concentrations Needed to Yield the Spokane Tribe Fish Tissue Criterion (0.1 ng/g) in the Spokane River, Based on the Arnot-Gobas Food web Bioaccumulation Model.

Reach	Target Tissue Total PCB Conc. (ng/g)	Target Sediment Total PCB Conc. (ng/g dw)	Target Dissolved Water Total PCB Conc. (pg/l)	Dissolved PCB Fraction	Target Whole Water Total PCB Conc. (pg/l)	Target Total PCB Load (mg/day)
Stateline-Upriver Dam	0.1	0.06	0.9	0.90	1.0	4.5
Monroe-Ninemile	0.1	0.06	0.6	0.88	0.7	4.9
Lake Spokane	0.1	0.05	1.7	0.83	2.0	18.7
Little Falls	0.1	0.02	0.7	0.83	0.8	7.7
Spokane Arm	0.1	0.04	1.3	0.83	1.6	14.3

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Conclusions

The overall goal of the Spokane River PCB Source Assessment was to gather representative data to quantify PCB contamination in Washington reaches of the Spokane River. Data were collected in a series of studies conducted between 2003 and 2007. The information collected is being used to (1) identify necessary reductions in PCB sources to meet applicable water quality criteria and (2) develop a strategy for reducing sources to the river.

Specific components of the study included:

- Obtain representative data on PCB concentrations and ancillary parameters in the Spokane River water column, NPDES- permitted discharges, bottom sediments, and fish tissue.
- Assess trends and recovery rates for PCBs in Spokane River sediments.
- Determine the Spokane River's loading capacity for PCBs.
- Evaluate a food web bioaccumulation model to predict the PCB concentrations in Spokane River fish.

Results of sampling during 2003 and 2004 indicate that average PCB concentrations in river water increase with successive reaches from the Idaho border (106 pg/l) to lower Lake Spokane (399 pg/l), with a corresponding eight-fold increase in loads (477-3,664 mg/day). Overall, PCB loading to Washington reaches of the river can be divided into the following source categories: City of Spokane stormwater (44%), municipal and industrial discharges (20%), and Little Spokane River (6%). In addition, PCB loading from Idaho at the state line represented 30% of the overall loading.

Current PCB concentrations in fish tissue are lower than they have been historically. This may be due in part to natural attenuation and significant reductions in point-source PCB contributions over the past 10 to 15 years. The lack of decline in PCB levels in fish from the Mission Park reach of the river supports the conclusion about the importance of stormwater as a PCB source. A food web bioaccumulation model was used to predict PCB concentrations in fish tissue from PCB levels in water and sediments. This model indicates that significant reductions in sediment PCB concentrations would be required to reduce fish tissue to a Spokane Tribe target concentrations at their reservation.

Analysis of sediment cores suggests that PCB concentrations at the sediment surface will decrease by one-half approximately every ten years in upper Lake Spokane, although patterns of material deposition upstream of Lake Spokane require further evaluation. Lower Lake Spokane may be the ultimate sink for fine sediments. In lower Lake Spokane, PCBs have decreased by one-half over two decades after steep declines during the 1960s to mid-1980s.

A load-reduction scenario exercise was developed to show the reductions in water PCB concentrations that would be required to meet the Spokane Tribe's target criterion of 3.37 pg/l at the point where the river runs through the Spokane Tribe's reservation. The scenario requires a 95% PCB load reduction in the Spokane River at the Idaho border. Industrial and municipal discharges between the Idaho border and Lake Spokane require PCB load reductions greater than

99%. Stormwater from the City of Spokane also requires a load reduction of >99%. A 97% PCB load reduction is required in the Little Spokane River.

The food web bioaccumulation model is a useful tool to back-calculate water and sediment concentrations that will result in a target fish tissue PCB concentration. This model was used to develop alternative water and sediment quality goals. The model predicts target PCB concentrations in water and sediment after a target PCB concentration in fish tissue has been established, which in this exercise was the Spokane Tribe PCB tissue criterion of 0.1 ng/g. Based on model-derived targets, all discharges would require PCB load reductions of ≥99% to meet target loads.

According to the food web model, water reductions of PCBs may not be enough to achieve the tribal goal. Large PCB reductions in sediments would also be required to meet a fish tissue target of 0.1 ng/g. Even with large reductions in PCBs, it seems unlikely that the Spokane Tribal target of 0.1 ng/g is achievable. This concentration is approximately an order of magnitude lower than the median level (1.4 ng/g) reported in fish tissue from background areas in a 2010 statewide study conducted by Ecology (Johnson et al., 2010). Despite the extremely low tribal criteria, it is clear that further reductions in PCB loading are probably achievable.

Recommendations

Even though significant reductions in PCB levels have been measured in the Spokane River since the 1980s, achieving further reductions in PCBs and other toxic chemicals will be a challenging long-term process. This process requires a comprehensive strategy which uses a combination of activities to reduce toxic chemical loading to the river. To start meeting this challenge, Ecology has drafted a long-term strategy for reducing PCBs and other toxic chemicals in the Spokane River watershed. This plan is called *Reducing Toxics in the Spokane River Watershed* (Ecology, 2009). This strategy can be found at the following link: www.ecy.wa.gov/geographic/spokane/images/clean_up_strategy_toxics_in_srws_82009.pdf.

The Spokane River Toxics Reduction Strategy requires coordination across several Ecology programs, including the Spokane River Urban Waters Program (UWP) which was formed in 2007, to identify and eliminate toxic chemicals at their source. The UWP also works cooperatively with local governments including the City of Spokane and the Spokane Regional Health District.

Under the reduction strategy, PCB source identification and control will largely be carried out by the UWP. The strategy uses a three-pronged approach (prevention, management, and cleanup) to reduce sources. Priority is placed on using a systematic step-wise process to identify potential PCB sources within a conveyance system; then reducing or eliminating sources as they are located. This approach has been used successfully by other cities on the West Coast including San Francisco and Portland.

The conceptual approach to reduce PCBs discharged to the Spokane River should continue to focus on:

5. Identifying PCB sources and reducing or eliminating them from stormwater and wastewater effluents.
6. Examining treatment alternatives for effluent PCB removal.
7. Implementing necessary treatment plant controls.
8. Characterizing PCB transport through groundwater.

In addition, PCB source reduction efforts should be coupled with an ongoing effectiveness monitoring program to evaluate progress in reaching water quality targets. Effectiveness monitoring data will be useful in implementing an adaptive management framework for the watershed.

Future Characterization Activities

Extensive work to characterize PCBs in the Spokane River has been conducted since 1999. Future sampling should consider how the data will be used to either reduce PCB concentrations in fish tissue or to determine how and where PCB reductions may occur. Several activities to consider include the following:

Source Tracing

The UWP and other groups should continue systematic PCB source tracing activities in high-priority conveyance systems (stormwater and municipal/industrial) to identify and eliminate sources where possible. Implementation of an adaptive management approach using narrative limits in NPDES permits should be explored as an option to establish a set of achievable targets for toxic chemical reductions.

Effectiveness Monitoring

Design and implement a coordinated effectiveness monitoring program to track progress in meeting water quality targets. This program should include periodic assessment of PCB concentrations both instream (in water, sediments, and fish tissue) and in discharges to the river.

Food Web Modeling

Refinement of the Arnot-Gobas food wed bioaccumulation model is needed to predict conditions necessary to reach PCB target outcomes in priority reaches of the river. Specifically, the model should be examined to determine if modifications to the organism component (both benthic and fish) of the model would yield more accurate outcomes.

The model should be examined to identify critical input parameters that need refinement. Fish diet is a particular area where data refinement is needed. Site-specific field data are preferred to literature values where available.

Output parameters (i.e., fish tissue) should also be analyzed concurrently to assess the model's accuracy. This appears to be particularly important considering the apparent rapid change in fish tissue PCB concentrations.

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Appendices

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Appendix A: Spokane River Basin NPDES Permits

Table A-1. Spokane River Basin NPDES Permits (active during Ecology's 2003-2007 PCB studies).

Facility Name	Permit Type	Permit Number	WRIA
Industrial Facilities			
Newman Lk Flood Control Zone Dist	Minor	WA0045438A	57
B F Goodrich	POTW	ST0008068A	57
Columbia Lighting Inc	POTW	ST0005222B	57
Group Photo	POTW	ST0005378A	57
Johnson Matthey Electronic	POTW	ST0005350B	57
Novation Inc	POTW	ST0005355B	57
Inland Empire Paper Co	Major	WA0000825B	57
Kaiser Trentwood	Major	WA0000892B	57
Dawn Mining Company	State	ST0005230C	54
Avista Corp Headquarters	Minor	WA0045195B	57
Johnson Matthey (Cheney)	POTW	ST0008055A	56
Key Tronic Corp (Spokane)	POTW	ST0005284B	57
Olympic Foods	POTW	ST0008051A	57
Spokane Co Util. (Mica Landfill)	POTW	ST0005356B	56
Wilcox Farms Inc. (Milk Plant)	POTW	ST0005399A	56
Municipal Facilities			
Badger Lake Estates	State	ST0008057B	56
Clayton Sewer District	State	ST0005392A	55
Freeman School District #358	Minor	WA0045403A	56
Liberty School District #362	State	ST0005397A	56
Mullen Hill Terrace Properties	State	ST0008041A	57
Snowblaze Condominiums	State	ST0008039A	57
Spokane Co Util. (Hangman Hills)	State	ST0008045A	56
Upper Columbia Academy	State	ST0008034A	56
Deer Park WWTP	State	ST0008016B	55
Diamond Lake WWTP	State	ST0008029C	55
Medical Lake RWTP	Minor	WA0021148A	54
Liberty Lake Sewer Dist #1	Minor	WA0045144B	57
Spokane AWWTP	Major	WA0024473A	54
Cheney WWTP	Minor	WA0020842B	56
Tekoa WWTP	Minor	WA0023141B	56
Fairfield Town of WWTP	Minor	WA0045489B	56
Rockford Town of WWTP	Minor	WA0044831B	56
Spangle Town of WWTP	Minor	WA0045471A	56

WRIA: Water Resource Inventory Area.
POTW: Publicly-Owned Treatment Works.
WWTP: Wastewater Treatment Plant.
RWTP: Rural Wastewater Treatment Plant.
AWWTP: Advanced Wastewater Treatment Plant.

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Appendix B: Sampling Locations for Spokane River PCB Source Assessment Study

Table B-1. Sampling Locations.

Station ID[1]	Sampling Dates	Sample Type	Location Description	RM	Latitude North		Longitude West
Stateline	10/1-29/2003	SPMD	Just downstream of the I-90 bridge at the Idaho state line	96.1	47° 41' 52 "		117° 2 ' 29 "
	1/28-2/24/2004			"	" " " "		" " " " "
	4/14-5/12/2004			"	" " " "		" " " " "
STATELINE-F	7/14/2004	Fish	Idaho state line boundary to first downstream riffle (coordinates at midpont)	96.0	47° 41' 54 "		117° 2 ' 33 "
Harvard	10/20-22/2003	SPM/Water	Near right bank below Harvard Road Bridge	92.8	47° 41' 2 "		117° 6 ' 34 "
LIBLAKE	10/21/2003	Effluent	Liberty Lake Wastewater Treatment Plant effluent*	92.3	47° 40' 40 "		117° 6 ' 44 "
KaiserEff	10/21-22/2003	Effluent	Kaiser effluent before discharge to river	86.0	47° 41' 5 "		117° 13 ' 16 "
	2/2-3/2004			"	" " " "		" " " " "
	4/26-27/2004			"	" " " "		" " " " "
KaiserFilt	10/21/2003	Effluent	Kaiser at Filter Outlet	86.0	47° 41' 6 "		117° 13 ' 17 "
	2/2/2004			"	" " " "		" " " " "
	4/26/2004			"	" " " "		" " " " "
KaiserLag	10/21/2003	Effluent	Kaiser Lagoon	86.0	47° 41' 6 "		117° 13 ' 16 "
	2/2/2004			"	" " " "		" " " " "
	4/26/2004			"	" " " "		" " " " "
PLANTE-F	9/15/2003	Fish	⅛ mi. upstream of RR bridge to riffle at lava boulders below park (coordinates at midpoint)	85.0	47° 41' 41 "		117° 14 ' 18 "
PLANTEFRY	10/28-30/2003	SPM/Water	Off right bank at Plante Ferry Park	84.8	47° 41' 52 "		117° 14 ' 41 "
Inland Emp	10/21/2003	Effluent	Inland Empire effluent*	82.6	47° 41' 13 "		117° 17 ' 2.8 "
	2/2-3/2004			"	" " " "		" " " " "
	4/26/2004			"	" " " "		" " " " "
Upriver Dam	10/1-29/2003	SPMD	⅛ mi. upstream of Upriver Dam, off right bank	80.3	47° 41' 13 "		117° 19 ' 29 "
	1/28-2/25/2004			"	" " " "	"	" " " " "
	4/14-5/12/2004			"	" " " "	"	" " " " "
	5/13/2004	Crayfish		"	" " " "	"	" " " " "

Table B-1 (Cont'd). Sampling Locations.

Station ID[1]	Sampling Dates	Sample Type	Location Description	RM	Latitude North					Longitude West				
UPRIVER BOT	10/1-29/2003	SPMD	Above Upriver Dam, off right bank, 2 feet from bottom of riverbed	80.3	47°	41'	13	"		117°	19	'	29	"
	1/28-2/25/2004			"	"	"	"	"	"	"	"	"	"	"
	4/14-5/12/2004			"	"	"	"	"	"	"	"	"	"	"
STMMISSBR	6/10/2004	Stormwater	Stormwater pipe near intersection of Mission and Perry on right bank	76.5	47°	40'	20	"		117°	23	'	20	"
STMSUPOUT	6/10/2004	Stormwater	Stormwater pipe at Superior Street near Cataldo on right bank	75.7	47°	39'	36	"		117°	23	'	32	"
CS034	6/10/2004	CSO	Combined sewer overflow (CSO) outfall at Erie Street	75.8	47°	39'	41	"		117°	23	'	30	"
MonroeSed	4/14/2004	Sediment	Approximately 60 feet off left bank at first bend upstream of Monroe Street Dam	74.9	47°	39'	52	"		117°	24	'	22	"
Monroe St	10/2-29/2003	SPMD	Upstream of Monroe Street Dam	74.8	47°	39'	48	"		117°	24	'	31	"
	1/28-2/25/2004			"	"	"	"	"	"	"	"	"	"	"
	4/14-5/12/2004			"	"	"	"	"	"	"	"	"	"	"
STMWASHBR	6/10/2004	Stormwater	Stormwater pipe at west side of Washington Street Bridge on right bank	74.3	47°	39'	51	"		117°	25	'	0.8	"
SPOKWWTP	10/21/2003	Effluent	Spokane Wastewater Treatment Plant effluent*	67.4	47°	41'	51	"		117°	28	'	32	"
	2/2/2004			"	"	"	"	"	"	"	"	"	"	"
	4/26/2004			"	"	"	"	"	"	"	"	"	"	"
Ninemile1	10/1-29/2003	SPMD	Ninemile reservoir above Plese Flats boat launch	63.6	47°	43'	15	"		117°	30	'	29	"
	1/28-2/24/2004			"	"	"	"	"	"	"	"	"	"	"
NINEM SPM	11/3-5/2003	SPM/Water	Off of right bank at Plese Flats, Riverside State Park	63.2	47°	43'	35	"		117°	30	'	43	"
Ninemile2	4/14-5/12/2004	SPMD	Ninemile Pool, downstream of boat launch at Plese Flats	62.4	47°	44'	9	"		117°	30	'	40	"
NINEMILE-F	9/16/2003	Fish Gut Contents	Ninemile reservoir near Seven Mile Bridge	61.7	47°	44'	35	"		117°	31	'	14	"
	7/13/2004	Fish		"	"	"	"	"	"	"	"	"	"	"
Spokane-F	9/16/2003	Fish		"	"	"	"	"	"	"	"	"	"	"
LongLkUp	5/11/2004	Sediment	Upper Long Lake (Lake Spokane)	54.3	47°	47'	38	"		117°	34	'	11	"

Table B-1 (Cont'd). Sampling Locations.

Station ID[1]	Sampling Dates	Sample Type	Location Description	RM	Latitude North					Longitude West				
LONGUP2	6/9/2004	Sediment Core	Upper Long Lake (Lake Spokane)	49.2	47°	50'	6	"		117°	39	'	3	"
LongLkMid	11/4/2003	Sediment	Middle Long Lake (Lake Spokane)	44.3	47°	53'	10	"		117°	41	'	28	"
Tum Tum	1/29-2/24/2004	SPMD	Long Lake right bank near Tum Tum	44.2	47°	53'	10	"		117°	41	'	38	"
Littlefls	11/4/2003	Sediment	Spokane River at pool above Little Falls Dam	29.9	47°	50'	10	"		117°	54	'	38	"
LONGLOW-F	7/13-14/2004	Fish	Lower Long Lake (Lake Spokane) off left bank approx. 1 mi. upstream of DNR launch	39.4	47°	49'	40	"		117°	44	'	39	"
LongLkLow	10/2-11/4/2003	SPMD	Lower Long Lake (Lake Spokane)	38.4	47°	49'	44	"		117°	46	'	8.2	"
	4/13-5/11/2004			"	"	"	"	"	"	"	"	"	"	"
	11/4/2003	Sediment		"	"	"	"	"	"	"	"	"	"	"
LONGLOW2	11/4/2003	Sediment Core	Lower Long Lake (Lake Spokane)	36.0	47°	48'	56	"		117°	48	'	25	"
SPOK-1	11/6/2003	Sediment	Porcupine Bay - NE of boat launch (upstream)	12.6	47°	53'	3	"		118°	8	'	59	"
LitlSpokSed	12/10/2003	Sediment	Little Spokane River approximately 1 mi. above SR291 bridge[2]	2.3	47°	46'	45	"		117°	31	'	0.9	"
LitlSpokBr	1/29-2/24/2004	SPMD	Little Spokane River @ SR291 bridge[2]	1.1	47°	46'	59	"		117°	31	'	44	"
	4/14-5/12/2004			"	"	"	"	"	"	"	"	"	"	"
LitlSpokR	10/2-30/2003	SPMD	Little Spokane River left bend in river, adjacent to SR291[2]	0.5	47°	47'	13	"		117°	31	'	38	"
BUFFALO REF	11/5/2003	Sediment	Buffalo Lake near lake center east of boat launch		48°	3'	56	"		118°	53	'	20	"

* Location coordinates in North American Datum 1983 (NAD83).
[1] Site identification as used in Ecology's Environmental Information Management System (EIM).
[2] The mouth of Little Spokane River is at Spokane River mile 56.3.
SPM: suspended particulate matter.
SPMD: semipermeable membrane device.
RM: river mile.

The additional fish collection locations and stormwater stations can be found in Tables 12 and 15 and the original reports, Serdar and Johnson (2006) and Parsons (2007) respectively.

Appendix C: Method Used to Convert PCB Concentrations in SPMD to Water

Background on SPMDs

Semipermeable membrane devices (SPMDs) are used to concentrate dissolved hydrophobic contaminants from the water column. Each SPMD consists of a 91 x 2.5 cm lay-flat, low-density polyethylene tube filled with 1 mL of highly purified triolein. The tube is thin-walled and generally considered nonporous except for small (≤ 10 Å) cavities created by the random thermal motions of the polymer chains (see Figure D-1). Freely dissolved hydrophobic contaminants are able to pass through the pores and are sequestered and concentrated in both the triolein and the polyethylene itself.

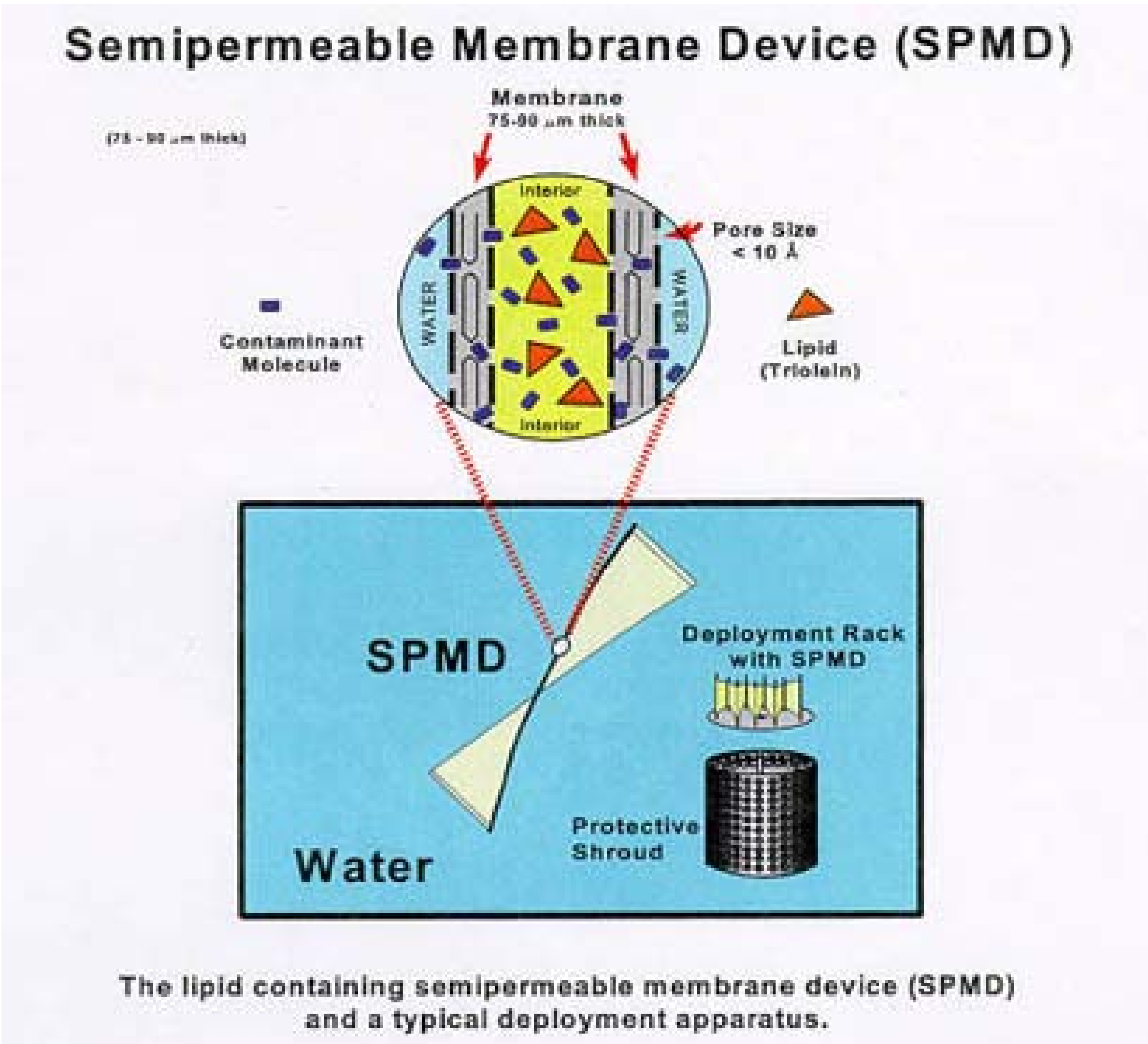

Figure C-1. Illustration of SPMD theory and mechanical design (*from* Duane Chapman, USGS Columbia Environmental Research Center, www.aux.cerc.cr.usgs.gov/spmd/index.htm)

The SPMDs are mounted on deployment racks (a.k.a. spider carriers) which permit nearly full exposure to surface water. From one to five spider carriers are then mounted inside a protective mesh-skinned stainless steel canister which is placed in the water column for approximately one month.

After removal from the water column, SPMDs are sent to a laboratory for dialytic extraction of the solutes. Prior to dialysis, material coating the SPMD (e.g., periphyton, sediments) is removed, and the membrane is inspected for holes and tears. The dialysate is concentrated to approximately 4 mL in a hexane solvent and stored in an ampule until it is ready for chromatographic or other analysis.

SPMDs are potent samplers of atmospheric organics which present major challenges in avoiding contamination while preparing, deploying, and dialyzing these samplers. To minimize contamination due to air exposure, SPMDs are stored in argon-filled cans following preparation except during their water deployment. Field blank SPMDs are also used to assess the degree of on-site contamination by exposing them to the atmosphere for the same duration as the inevitable exposure of the water sampling SPMDs. Laboratory blank SPMDs are also prepared and analyzed to assess the degree of contamination from the lab environment.

Performance reference compounds (PRCs) are spiked into each membrane prior to deployment to assess sampling rates. The recovery of PRCs, along with other factors such as temperature, water velocity, degree of biofouling, and exposure duration, is used to adjust the site/event-specific sampling rate from sampling rates determined in a laboratory setting. This adjustment factor, commonly referred to as the exposure adjustment factor (EAF), can be applied to the algorithms used to translate chemical concentrations in membrane extract to concentrations in the waterbody sampled.

Methods Used for the 2003-2004 Spokane River PCB Source Assessment Study

Field Blanks

Field (air) blanks were used to adjust SPMD results to account for laboratory and field contamination. The field blank was used for this purpose because it integrates contamination stemming from the field as well as the laboratory. Results for field blanks used during each round of sampling were subtracted (on a per membrane basis) from the sample results.

Exposure Adjustment Factors

PRCs were spiked into all membranes prior to deployment. Selection of PCB congeners for PRCs was based on the congeners found during recent effluent and fish tissue sampling in the Spokane River (Golding, 2002; Jack and Roose, 2002). Four congeners, which were absent or only present in very small amounts in these previous analyses, were used for the spiking solution: PCB-23, 55, 106, and 161. A total of 50 ng of each PRC was spiked into each membrane.

Average PRC recovery was higher than anticipated at 94%. More than a quarter of the PRCs were recovered at ≥100%. Subsequent consultation with Dr. David Alvarez and Dr. Jim Huckins of the USGS Columbia Environmental Research Center indicated that the fugacity of these congeners is too low to be suitable for calculation of EAFs (PCB-4 and 23 were recommended). Instead, they proposed using laboratory-derived sampling rates to calculate water concentrations.

Calculation of PCB Concentrations in Water

The following equation is the formula, in its simplest form, used to translate chemicals in SPMDs to water column concentrations:

$C_W = C_{SPMD} / K_{SPMD} (1\text{-exp} [-k_e t])$

Where:
C_W = analyte concentration in water
C_{SPMD} = analyte concentration in the SPMD
K_{SPMD} = equilibrium SPMD-water partition coefficient
k_e = first-order loss rate constant
t = time

Derivation of each term is beyond the scope of the present report but can be found at:

wwwaux.cerc.cr.usgs.gov/spmd/SPMD-Tech_Tutorial.htm#MODELING

or in:

Huckins, J.N. Petty, J.D., Priest, H.F., Clark, R.C., Alverez, D.A., Orazio, C.E., Lebo, J.A., Cranor, W.L., and Johnson, B.T, 2000. A Guide for the Use of Semipermeable Membrane Devices (SPMDs) as Samplers of Waterborne Hydrophobic Organic Contaminants. Report for the American Petroleum Institute (API), Washington, D.C. API Publication No. 4690.

To facilitate translation of SPMD analyte concentrations to water, David Alvarez has developed a spreadsheet which requires relatively few input parameters to make the necessary calculations. Necessary input parameters are temperature, exposure duration, volume and mass of SPMD, total mass of analyte in SPMD, and EAF if PRCs are used to adjust sampling rates. The spreadsheet includes default values for Log K_{ow} and for laboratory sampling rates in cases where EAFs are not used (Table C-1). All calculations are made using the input parameters and the default values in Table C-1 and using the river conditions and exposure periods described earlier in this report. Total analyte mass by PCB homologue group is shown in Table C-2.

Table C-1. Log K_{ow} and Sampling Rates Used to Calculate PCB Concentrations in Water.

Individual PCB Congeners	Log K_{ow}		Laboratory Sampling Rate (L/d)
4	5.1	k,m	12.8
5	5.1	k,m	12.8
6	5.1	g	12.8
7	5.1	k,m	12.8
8	5.1	k,m	12.8
9	5.1	k,m	12.8
10	5.1	k,m	12.8
11	5.1	k,m	12.8
15	5.1	k,m	12.8
16	5.5	k,m	6.7
17	5.5	k,m	6.7
18	5.2	g	9.2
19	5.0	g	5.3
20	5.5	k,m	6.7
22	5.6	g	5.7
24	5.5	k,m	6.7
25	5.7	g	5.7
26	5.7	g	5.7
27	5.5	k,m	6.7
28	5.7	g	8.4
31	5.7	g	7.0
32	5.5	k,m	6.7
33	5.5	k,m	6.7
34	5.5	k,m	6.7
35	5.5	k,m	6.7
37	5.5	k,m	6.7
40	5.7	g	6.6
41	5.7	g	6.2
42	5.8	g	6.2
43	5.8	g	6.2
44	5.8	g	7.5
45	5.5	g	7.9
46	5.5	g	4.4
47	5.8	g	7.5
48	5.8	g	3.5
49	5.8	g	5.3
51	5.6	g	4.8
52	5.8	g	6.2
53	5.6	g	4.8
54	5.9	k,m	5.7

Table C-1 (Cont'd). Log K_{ow} and Sampling Rates Used to Calculate PCB Conc. in Water.

Individual PCB Congeners	Log K_{ow}		Laboratory Sampling Rate (L/d)
55	5.9	k,m	5.7
56	5.9	k,m	5.7
57	5.9	k,m	5.7
58	5.9	k,m	5.7
59	5.9	k,m	5.7
60	5.9	k,m	5.7
63	6.2	g	5.3
64	6.0	g	7.5
66	6.2	g	5.3
67	6.2	g	5.3
69	5.9	k,m	5.7
70	6.2	g	7.0
71	5.9	k,m	5.7
72	5.9	k,m	5.7
74	6.2	g	6.2
75	5.9	k,m	5.7
77	6.2	a, h	2.9
78	6.4	a, h, k	4.4
79	6.4	a, h, k	5.1
81	6.4	g, h	4.3
82	6.2	g	4.4
83	6.3	g	4.8
84	6.0	g	4.4
85	6.3	g	4.8
86	6.4	k,m	4.7
87	6.3	g	5.3
90	6.4	g	6.2
91	6.1	g	4.4
92	6.4	g	5.3
95	6.1	g	6.2
96	6.4	k,m	4.7
97	6.3	g	4.4
99	6.4	g	4.4
101	6.4	g	6.2
102	6.4	k,m	4.7
105	6.6	g	4.0
107	6.7	g	5.3
109	6.4	k,m	4.7
110	6.5	g	5.7
112	6.4	k,m	4.7
113	6.4	k,m	4.7

Table C-1 (Cont'd). Log K_{ow} and Sampling Rates Used to Calculate PCB Conc. in Water.

Individual PCB Congeners	Log K_{ow}		Laboratory Sampling Rate (L/d)
114	6.6	g	4.4
115	6.4	k,m	4.7
117	6.4	k,m	4.7
118	6.7	g	4.8
119	6.6	g	4.4
122	6.4	k,m	4.7
123	6.4	k,m	4.7
126	6.7	a, h, k	2.2
127	6.7	a, h, k	1.6
128	6.7	g	4.4
129	6.7	g	3.5
130	6.8	g	4.0
131	6.8	k,m	4.1
132	6.8	k,m	4.1
133	6.8	k,m	4.1
134	6.6	g	4.8
136	6.2	g	5.3
137	6.8	g	3.5
138	6.8	g	4.8
139	6.8	k,m	4.1
141	6.8	g	4.8
144	6.8	k,m	4.1
146	6.9	g	4.8
147	6.8	k,m	4.1
149	6.7	g	5.7
151	6.6	g	5.3
153	6.9	g	3.2
156	7.2	g	2.6
157	7.2	g	2.6
158	7.0	g	3.5
163	6.8	k,m	4.1
164	6.8	k,m	4.1
166	6.8	k,m	4.1
167	6.8	k,m	4.1
169	7.4	a, h	2.1
170	7.1	k,m	2.6
171	7.1	k,m	2.6
172	7.3	g	1.3
173	7.1	k,m	2.6
174	7.1	g	3.1
175	7.1	k,m	2.6

Table C-1 (Cont'd). Log K_{ow} and Sampling Rates Used to Calculate PCB Conc. in Water.

Individual PCB Congeners	Log K_{ow}		Laboratory Sampling Rate (L/d)
176	6.8	g	2.2
177	7.1	k,m	2.6
178	7.1	g	3.1
179	6.7	g	2.2
180	7.4	g	2.6
183	7.2	g	3.1
185	7.1	k,m	2.6
187	7.2	g	3.5
189	7.1	k,m	2.6
190	7.1	k,m	2.6
191	7.1	k,m	2.6
193	7.1	k,m	2.6
194	7.8	g	1.3
195	7.6	k,m	1.6
196	7.6	k,m	1.6
197	7.6	k,m	1.6
198	7.6	k,m	1.6
199	7.6	g	1.6
200	7.6	k,m	1.6
201	7.3	g	1.6
202	7.6	k,m	1.6
203	7.6	k,m	1.6
205	7.6	k,m	1.6
206	7.7	k,m	1.6
207	7.7	g	1.6
208	7.7	k,m	1.6
Total PCB [g, h]	6.4	g, h	4.8

Compounds are listed in general order of their chromatographic elution on a DB-35MS and a DB-5 GC-column for the organochlorine pesticides and PAHs respectively.

The linear model of estimation was used in cases where a compound's log K_{ow}>6.

This calculator applies only to SPMDs which conform to the surface area-to-volume ratio of a standard SPMD.

If multiple log K_{ow} values were found in the literature, a mean value was selected using the t test at 95% Confidence for rejection of outliers.

[a] Mackay, D.; Shiu, W-Y; Ma, K-C. Illustrated Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals. Volume V, Lewis Publishers, Boca Raton, 1997.

[g] Meadows, J.C.; Echols, K.R.; Huckins, J.N.; Borsuk, F.A.; Carline, R.F.; Tillit, D.E. Environ. Sci. Technol., 1998, 32, 1847-1852.

[h] Rantalainen, A.L.; Cretney, W.; Ikonomou, M.G. Chemosphere, 2000, 40, 147-158.

[k] Log K_{ow} values estimated from similar congeners.

[m] R_s values estimated as the average of known R_s values of similarly substituted congeners

Table C-2. PCB homologue groups in SPMDs (pg per membrane)

Station Name	Sample Number	1-Cl	2-Cl	3-Cl	4-Cl	5-Cl	6-Cl	7-Cl	8-Cl	9-Cl	10-Cl	Total PCBs
October												
STATELINE	474155	42	729	2,117	2,557	7,628	2,173	602	108	0	0	15,957
UPRIVER DAM	474156	74	2,385	4,787	4,196	4,194	970	237	0	0	0	16,843
UPRIVER DAM(REP)	474157	71	2,301	5,208	4,272	4,565	1,324	323	0	0	0	18,063
UPRIVER BOT	474158	35	1,994	6,125	7,974	5,888	1,476	365	35	0	0	23,891
MONROEST	474159	64	4,159	6,224	9,594	9,033	4,940	1,312	128	0	0	35,454
NINEMILE	474160	39	6,847	12,144	10,254	13,492	5,864	1,605	144	0	0	50,389
LONGLOW	474161	80	7,395	14,935	51,689	32,233	10,102	2,747	484	30	0	119,693
LITTLSPOK	474162	0	634	3,605	5,814	5,191	2,321	849	514	69	0	18,998
LITTLSPMS	474163	41	154	1,336	3,217	4,352	1,415	989	450	74	0	12,030
February												
STATELINE	194130	0	24	359	767	1,982	1,007	373	0	0	0	4,511
UPRIVER DAM	194131	7	337	1,126	2,089	2,025	441	1,384	0	0	0	7,409
UPRIVER DAM(REP)	194132	0	125	86	271	338	62	6	0	0	0	888
UPRIVEBOT	194133	2	176	2,087	6,796	3,158	486	69	0	0	0	12,774
MONROEST	194134	0	561	1,903	3,596	2,873	1,552	841	0	0	0	11,326
TUMTUM	194135	4	698	2,317	3,834	2,368	988	895	6	0	0	11,109
LSPOKBR	194136	10	274	2,323	6,929	7,818	2,096	1,146	598	84	0	21,278
LSPOKBRMS	194137	14	83	1,063	4,342	5,711	1,388	639	477	60	0	13,778
April												
STATELINE	208134	0	61	1,564	2,781	8,261	3,737	2,022	88	0	0	18,513
UPRIVER DAM	208135	0	0	411	2,663	2,001	748	350	36	0	0	6,208
UPRIVER BOT(REP)	208137	75	432	5,345	11,499	6,211	1,898	758	48	0	0	26,266
UPRIVER BOT	208136	343	184	4,330	14,517	9,800	2,144	902	0	0	0	32,219
MONROE ST	208138	17	815	4,211	8,830	11,189	4,663	2,299	176	0	0	32,198
NINEMILE2	208139	49	1,202	4,870	9,609	9,742	4,747	2,079	174	0	0	32,470
LONGLKLOW	208133	62	3,086	5,083	15,707	12,072	4,026	1,211	143	0	0	41,389
LITLSPOKBR	208140	0	261	3,560	8,285	9,617	2,779	1,424	720	131	0	26,778
LSPOKBRMS	208141	65	367	3,491	4,126	5,386	1,464	2,071	581	91	70	17,712

REP: replicate.

Appendix D: Ancillary Parameters for Suspended Particulate Matter Sampling

Table D-1. Ancillary Data Taken at Centrifuge Locations During Suspended Particulate Matter Sampling (mg/L).

Station Name	Sample Number	Collection Date	TOC		DOC		TSS	
			inlet	outlet	inlet	outlet	inlet	outlet
Harvard								
	3438100	10/20/03	1.2	---	---	---	2	---
	3438101	10/21/03	1.1	---	---	---	1 U	---
	3438102		1.2	---	---	---	1	---
	3438103		1.1	---	---	---	1	---
	3438104		---	1.2	---	---	---	1 U
	3438105	10/22/03	1.1	---	---	---	1	---
	3438106		1.2	---	---	---	1 U	---
	3438107		---	2.3	---	---	---	1 U
PLANTEFRY								
	3448100	10/28/03	1.1	---	1.1	---	1	---
	3448101	10/29/03	1.1	---	1	---	3	---
	3448102		1.1	---	1	---	1	---
	3448103		---	1.1	---	1 U	---	1 U
	3448104		1.1	---	1	---	2	---
	3448105	10/30/03	---	1	---	1 U	---	1 U
	3448106		1.1	---	1	---	2	---
NINEM SPM								
	3454105	11/3/03	1	---	1 U	---	1	---
	3454106	11/4/03	1 U	---	1 U	---	1	---
	3454107		1 U	---	1 U	---	1	---
	3454108		---	1 U	---	1 U	---	1 U
	3454109		1 U	---	1 U	---	2	---
	3454128	11/5/03	1 U	---	1 U	---	1	---
	3454129		---	1 U	---	1 U	---	1 U

U: Undetected at value shown.

Appendix E: Biological Data for Fish and Crayfish Specimens Used for PCB Analysis

Table E-1. Biological Data for Plante Ferry Rainbow Trout Fillet Specimens.

Fillet Sample No.	Field ID	Date Collected	Total Length (mm)	Fork Length (mm)	Weight (g)	Fillet Weight (g)	Sex	Age (yrs)	Comments on Sex
188308	PF6	9/15/03	404	387	640	206	M	nd	
	PF8		365	350	552	190	M	nd	
	PF11		407	394	714	214	M	4	
	PF14		359	342	454	206	Imm. M?	3	
	PF15		323	308	363	126	M	3	
	PF16		300	284	291	106	M	2	
	PF17		380	364	582	212	M	3	
	PF18		422	401	782	202	M	3	
	PF23		345	328	452	126	Imm. M?	2	
	PF27		321	301	332	136	Imm. M?	2	
		Mean=	**363**	**346**	**516**	**172**		**3**	
188309	PF4	9/15/03	385	363	551	196	F	3	eggs visible
	PF5		410	387	670	208	F	4	eggs visible
	PF13		388	369	585	238	F	3	eggs visible
	PF19		412	385	667	210	F	4	eggs visible
	PF20		427	408	760	258	F	3	eggs visible
	PF21		376	356	583	178	F	3	eggs visible
	PF22		387	366	560	178	F	4	eggs visible
	PF24		378	359	517	220	F	3	eggs visible
	PF25		401	387	663	216	F	3	eggs visible
	PF26		345	325	427	202	F	2	eggs visible
		Mean=	**391**	**371**	**598**	**210**		**3**	

Imm. = Immature